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SSALTO

ALGORITHM DEFINITION, ACCURACY AND SPECIFICATION
VOLUME 2 : CMA ALTIMETER LEVEL 1B PROCESSING

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Issue	Update	Date	Modifications	Visa
0	0	30th July, 1998	Document creation	
1	0	9th April, 1999	Accounting for the algorithms specifications, and for conclusions of the Jason-1 meeting (Keystone, October 1998)	
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3	1	05th January 2001	Modification of the initialisation of NAG algorithms (ALT_CAL_PTR_03 and ALT_CAL_GEN_02)	
3	2	18th Octobre 2001	Accounting for comments from JPL (November 22, 2000)	

ABBREVIATIONS

Abbreviation	Definition
ADA	Algorithm Definition and Accuracy
ADx	Applicable Document x
AGC	Automatic Gain Control
CAL	Calibration
CLS	Collecte Localisation Satellites
CMA	Centre Multi-missions Altimètre
CNES	Centre National d'Etudes Spatiales
COG	Center Of Gravity
DAD	Dynamic Auxiliary Data
DC	Direct Current
DS	Data Set
FFT	Fast Fourier Transform
FIR	Finite Impulse Response
GDR	Geophysical Data Record
GPS	Global Positioning System
IGDR	Interim Geophysical Data Record
JPL	Jet Propulsion Laboratory
LNA	Low Noise Amplifier
LPF	Low-Pass Filter
LS	Least Square
LTM	Long Term Monitoring
N/A	Not Applicable
NGDC/WDC-A	National Geophysical Data Center/World Data Center A
NRT	Near Real Time
OFL	Off-Line
PF	PlatForm
PTR	Point Target Response
RMS	Root Mean Square
RDx	Reference Document x
Rx	Reception path
SAD	Static Auxiliary Data
SGDR	Sensor Geophysical Data Record
SNR	Signal to Noise Ratio
SSALTO	Segment Sol ALTimétrie et Orbitographie
SSPA	Solid State Power Amplifier
SWH	Significant WaveHeight
SWT	Science Working Team
TEC	Total Electron Content
TBC	To Be Confirmed

Abbreviation	Definition
TBD	To Be Defined
TC	Telecommand
Tx	Transmission path
USO	Ultra-Stable Oscillator
UTC	Universal Time Coordinate

APPLICABLE AND REFERENCE DOCUMENTS

Reference		Document title
TP2-SB-J0-102-CNES	AD1	JASON-1 Science and Operational Requirements
SMM-ST-M2-EA-10658-CN	AD2	CMA Requirements Specification
SMM-ST-M-EA-10879-CN	AD3	SSALTO Products Specifications - Volume 1: JASON-1 User Products
TP2-SB-J0-459-CNES	AD4	JASON-1 Products Description
SMM-MIF-M-EA-20054-CN	AD5	Manuel des Interfaces
SMM-ST-M1-EA-20078-CN	AD6	POSEIDON-2 Level 1.0 Altimeter data product
SMM-ST-M1-EA-20080-CN	AD7	POSEIDON-2 Level 1.0 PTR data product
SMM-ST-M1-EA-20079-CN	AD8	POSEIDON-2 Level 1.0 LPF data product
SMM-IF-M/JALT-EA-11870-CN	AD9	Spécifications d'interface entre SSALTO et les experts altimètre
SMM-IF-M2-EA-20207-CN	AD10	SSALTO internal Interfaces specification : CMA (CAL & TEC products)
SMM-ST-M2-EA-11010-CN	AD11	Algorithm Definition, Accuracy and Specification Volume 9: CMA Mechanisms
TP-ST-6135-340-CLS	RD1	Spécifications des algorithmes de la chaîne de traitement des données de calibration, Issue 2 Rev. 0
TP-ST-6135-266-CLS	RD2	Spécifications des algorithmes de la chaîne de traitement des données altimètriques du niveau 1.0 au niveau 1.1, Issue 4 Rev. 0
TP-ST-6135-320-CLS	RD3	Spécifications des algorithmes de la chaîne de traitement des données altimètriques du niveau 1.1 au niveau 1.5, Issue 4 Rev. 0
SMM-ST-M2-EA-11005-CN	RD4	Algorithm Definition, Accuracy and Specification Volume 4: CMA Altimeter Level 2 Processing
ALT-SP-1000-003-ATS	RD5	Définition de l'interface informatique de l'altimètre POSEIDON 2 (commande / télémesure), Issue 7 Rev. A
TP2-SB-JALT1-EA-120-CNES	RD6	Spécification technique de besoin de l'altimètre POSEIDON-2, Issue 3 Rev. A
SMM-ST-M2-EA-11009-CN	RD7	Algorithm Definition, Accuracy and Specification Volume 8: Off Line Control Processing
ALT-SP-1000-005-ATS	RD8	POSEIDON-2: Specification Technique des Algorithmes de Traitement, Issue 5 Rev. A
SMM-ST-M2-EA-11002-CN	RD9	Algorithm Definition, Accuracy and Specification Volume 1: JASON Real Time processing
SMM-ST-M2-EA-11011-CN	RD10	Algorithm Definition, Accuracy and Specification Volume 10: CMA Expertise processing
SMM-SP-M2-EA-32012-CLS	RD11	CMA production: Specifications of the Data management Algorithms

Reference	Document title
TBD	RD12 TBD (Features of the thermal control of the platform)
	RD13 NAG Fortran Library Manual – Mark 18

TBC AND TBD LIST

TBC/TBD	Section	Brief description
TBD	Applicable and reference documents	Nomenclature and title of RD12
TBC	ALT_PHY_RAN_02 - To compute the tracker ranges	Integer conversion used on-board
TBC and TBD	ALT_COR_WAV_01 - To correct the waveforms for the filtering effects	Processing
TBC	ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates ALT_COM_RAN_02 - To edit and compress the USO frequency correction on the altimeter range ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation	Accuracy of algorithms (not critical)
TBD	ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived) ALT_COR_RAN_03 - To compute the corrected tracker ranges ALT_COR_RAN_04 - To compute the corrected on-board retracked altimeter ranges ALT_COR_RAN_05 - To compute the corrected tracker range rates ALT_COR_SWH_01 - To compute the corrected on-board retracked significant waveheights ALT_COR_BAC_01 - To compute the corrected on-board retracked backscatter coefficients	Accuracy of algorithms (not critical)

CONTENTS

1. INTRODUCTION

This document is aimed at defining and specifying the main functions of the nominal Level 1b processing of the JASON-1 altimeter (POSEIDON-2) data.

Regarding the JASON-1 mission, the highest level requirements placed by the JASON Science Working Team upon the JASON project to meet the scientific and operational objectives of the mission are listed in AD1, and the requirements aimed at defining the CMA facility inside the SSALTO system are established in AD2.

From the description of JASON-1 products given in AD4, the level 1b processing may be split into two procedures:

- The CAL processing, which is aimed at providing the level 1b POSEIDON-2 internal calibration parameters, i.e. the features of the low-pass filter (LPF) and of the point target response (PTR) of the POSEIDON-2 altimeter, from the level 1.0 POSEIDON-2 internal calibration data.
- The ALT processing, which is aimed at providing the POSEIDON-2 level 1b parameters, i.e. the altimeter parameters with instrumental and internal calibration corrections applied, from the level 1.0 POSEIDON-2 parameters, using in particular the outputs of the long term monitoring of the level 1b POSEIDON-2 internal calibration data.

The definition and the specification of the CAL and ALT procedures are derived from the specifications of the corresponding POSEIDON-1 processing (RD1, RD2 and RD3), accounting for the evolution of POSEIDON-2 with respect to POSEIDON-1 (RD6 and RD5).

As previously mentioned, this document deals with both the definition of the altimeter level 1b procedures and the specification of their main functions.

Definition of the altimeter level 1b procedures

The definition of the altimeter level 1b procedures consists of the identification and the description of their main functions. It will provide the reader with an overview of the procedures and a global understanding of the algorithms.

Specifications of the altimeter level 1b procedures

Regarding the specifications of the altimeter level 1b procedures, two kinds of algorithms are distinguished:

- The “scientific” algorithms, which represent the core of the processing
- The other algorithms, which will be called the “data management” algorithms, ensuring functions such as:
  - To get the input data
  - To prepare the data to be processed (for example to select the orbit data set requested to compute the location of each altimeter measurement)
  - To perform unit conversions or changes in reference systems
  - To perform general checks (relevant for example to the presence of input files, to the data conformity or to the compatibility of input data with the data set to be processed)
  - To build the output product(s)
  - To manage the processing

The scientific algorithms are specified in this document and in AD11 for the mechanisms, which represent the functions common to several algorithms or the functions frequently requested within an algorithm. The data management algorithms, which strongly depend on the format of the input and output data, are specified RD11 (and AD11 for the corresponding mechanisms, if any). The complete set of specifications (to be associated with the corresponding interfaces documents) are intended for the team in charge of the software development.

Conventions

The level 1b CAL and ALT procedures are represented in this document as linear sets of functions which are aimed at building a set of level 1b parameters from a set of level 1.0 parameters. This representation has been chosen for historical reasons in order to ease the understanding of the overall procedures, but it does not anticipate the organization or the sequencing of the algorithms within the CMA processor.

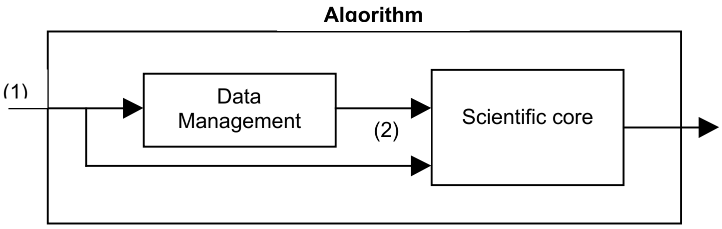
Organization of the document

- The product tree pointing out the main features of the JASON-1 level 1b procedures (grey cells) and of the corresponding output data levels is given in **Figure 1**.
- The interfaces of the procedures (input and output data) are defined in § 2.
- The CAL processing is described in § 3
- The ALT processing is described in § 4
- For a better understanding of this document together with RD4, the management of instrumental corrections in the JASON-1 altimeter procedures in the particular case of a production scenario in three successive steps (Level 1b, IGDR and GDR) is clarified in Appendix 1.

For each one of the two level 1b procedures (CAL, ALT), the description consists of:

- An overview of the overall processing (brief description of the processing and list of functions).
- The definition and the specification of the algorithms, using the following items:
  - Name and identifier of the algorithm
  - Heritage
  - Function
  - Applicability to the various procedures
  - Algorithm definition:
    - Input data
    - Output data
    - Mathematical statement
  - Algorithm specification:
    - Input data
    - Output data
    - Processing
    - Accuracy (if any)
  - Comments (if any)
  - References (if any)

As previously mentioned, only the scientific core of each algorithm is specified in this document. For each algorithm, the input data (1) identified in the "Algorithm definition" section corresponds to the input data required for the global processing (Data Management and Scientific Core), while the input data (2) identified in the "Algorithm specification" section corresponds to the data requested for the scientific core only.



The general information necessary for a global understanding of the algorithm within the overall processing is provided in the “Algorithm definition” sections.

The detailed information required by the team in charge of the software development is provided in the “Algorithm specification” sections, which precisely define the scientific part (i.e. the core) of the algorithms.

Basic rules

The following basic rules are applied to the specification of the algorithms:

- The specifications of an algorithm are always relevant to the processing of a single data point and not to a set of data points
- Elementary functions that are common to several algorithms (also called “mechanisms”) are specified in AD11.
- The input and output data are always identified by a precise description, an explicit name (that could be used in the coding phase), a unit and, if necessary, a reference system
- Regarding the errors that may occur during the processing functions (for example, negative argument for logarithmic or square root functions), the algorithms systematically output an execution status. The building and the management of this information will be defined during the architectural design of the software.
- Regarding the representation of tables, the following conventions are used in the following:
  - $X[N_1:N_2]$ represents a one-dimension table whose elements are $X(i)$ (or X_i) with $i \in [N_1, N_2]$
  - $X[N_1:N_2][M_1:M_2]$ represents a two-dimension table whose elements are $X(i,j)$ (or X_{ij}) with $i \in [N_1,N_2]$ and $j \in [M_1,M_2]$
  - And so on

Terminology

In this document, an altimeter "elementary measurement" refers to each individual measurement performed every 50 ms for POSEIDON-2 in nominal tracking operation. An "averaged measurement" refers to the compression of 20 elementary measurements (every 1 s for POSEIDON-2). The elementary measurements are sometimes also referred to as the 20-Hz measurements, and the averaged measurements are sometimes also referred to as the 1-Hz measurements.

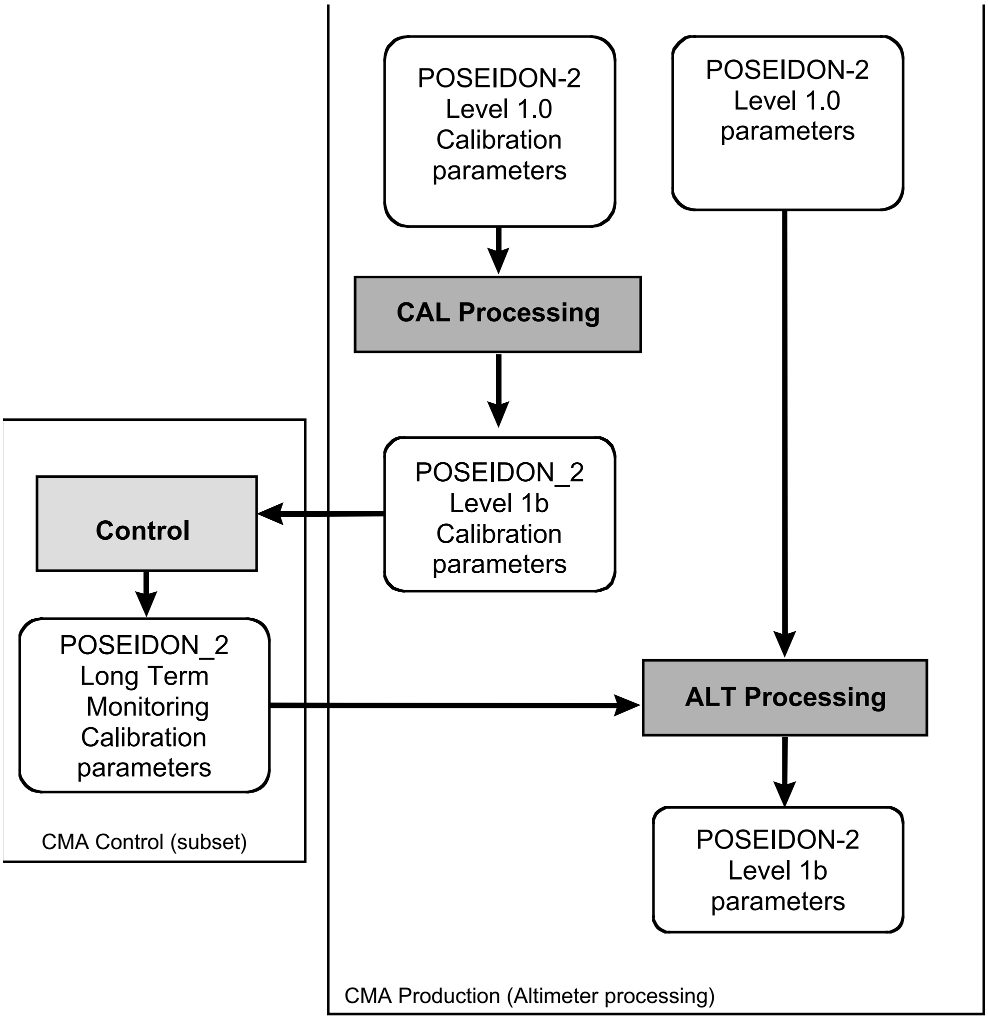


Figure 1: Product tree (CMA level 1b altimeter processing)

2. INPUT AND OUTPUT DATA

2.1. INPUT DATA

Two types of input data may be discriminated (see AD2):

- "Product" data, which correspond to measurements performed by the altimeter:
  - POSEIDON-2 level 1.0 calibration parameters, for CAL processing
  - POSEIDON-2 level 1.0 parameters, for ALT processing
- Auxiliary data, which may be dynamic or static:
  - Dynamic auxiliary data (DAD) are the time-varying data
  - Static auxiliary data (SAD) are constant data.

For CAL and ALT procedures, the altimeter dataset on input represents a sequential set of measurements.

2.1.1. PRODUCT DATA

The JASON-1 altimeter level 1.0 calibration parameters are described in AD7 (PTR) and AD8 (LPF).

The JASON-1 altimeter level 1.0 parameters are described in AD6.

2.1.2. AUXILIARY DATA

- **Dynamic auxiliary data:**

  Dynamic auxiliary data for JASON-1 level 1b processing consist of:

  – Platform data (POSEIDON-2 off-nadir angle and distance antenna-COG), described in AD5 (1)

  – DORIS-derived data (USO frequency), described in AD5

  – POSEIDON-2 LTM calibration parameters (features of the PTR and of the LPF), described in AD10.

  The dynamic auxiliary data required on input of the level 1b procedures must be the data that at least cover the time span of the input dataset to be processed.

- **Static auxiliary data:**

  Static auxiliary data for JASON-1 level 1b procedures consist of:

  – The following POSEIDON-2 features, described in AD9:

    * POSEIDON-2 instrumental characterization data

    * Instrumental corrections tables, built from a simulator of the altimeter and from the on-board retracking algorithm, accounting in particular for all the instrumental features provided by the POSEIDON-2 internal calibration (PTR and LPF)

  – The following data, described in AD10:

    * Universal constant data

    * Processing parameters (all the constant parameters used in the processing)

    * Land/sea mask

2.2. OUTPUT DATA

It is assumed that level 1b CAL and ALT procedures do not modify the organization of the input data. Therefore, level 1b processing outputs one set of level 1b parameters that is structured identically to the set of input parameters.

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(1) No correction of platform data is planned in the JASON-1 processing. It means that these data take into account the possible perturbations due the movement of solar arrays (rotation and bending).

- JASON-1 altimeter level 1b calibration parameters:

  The JASON-1 POSEIDON-2 Level 1b calibration parameters consist of the POSEIDON-2 level 1.0 calibration parameters required on input of the LTM processing (see RD7) and of the parameters computed by the POSEIDON-2 level 1b algorithms (calibration).

  These parameters are considered as intermediate parameters within a global processing of the altimeter calibration measurements from level 1.0 (see AD7 and AD8) to LTM (see AD10).

- JASON-1 altimeter level 1b parameters:

  The JASON-1 POSEIDON-2 Level 1b parameters consist of the POSEIDON-2 level 1.0 parameters required on input of the IGDR processing and of the parameters computed by the POSEIDON-2 level 1b algorithms.

  These parameters are considered as intermediate parameters within a global processing of the altimeter (and radiometer) measurements from level 1.0 (see AD6) to IGDR (see AD3).

2.3. SUMMARY OF THE INTERFACES

The interfaces of the JASON-1 CAL and ALT procedures are summed up in **Figure 2**.

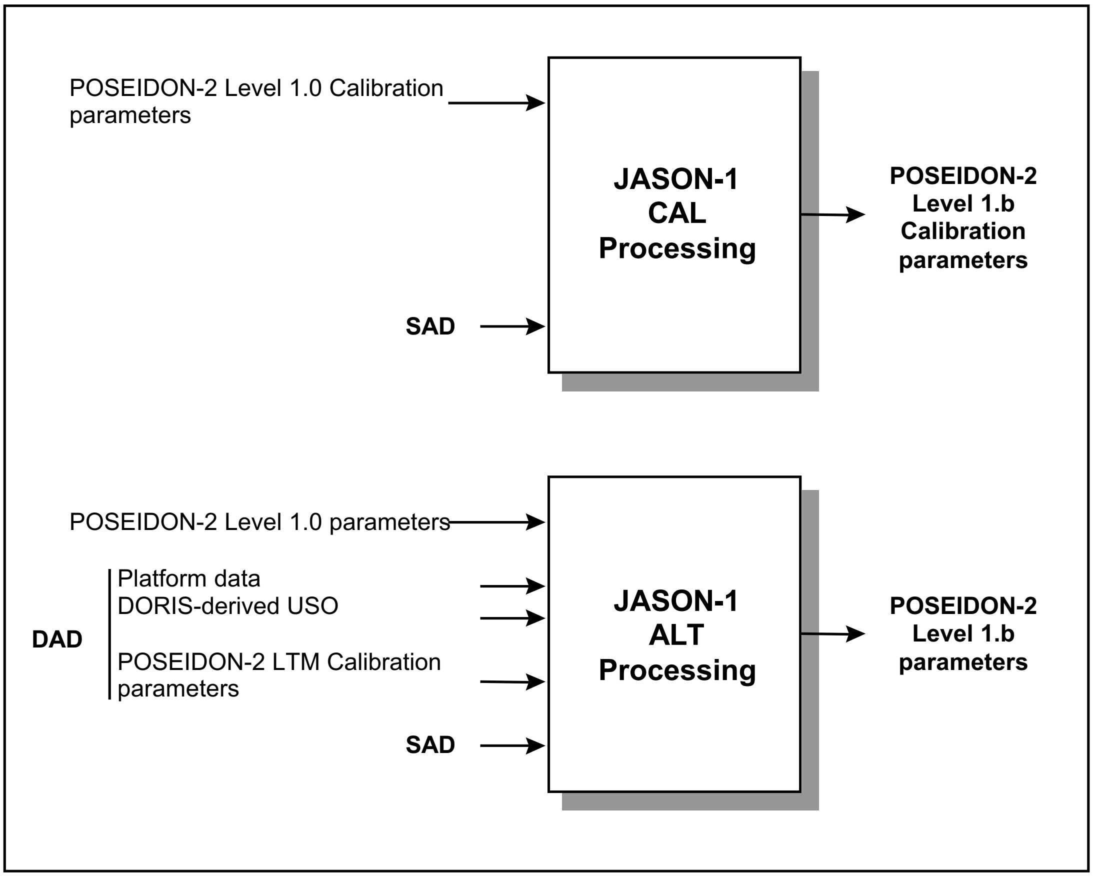

Figure 2: Interfaces of the CMA level 1b altimeter processing

3. "CAL" PROCESSING

3.1. PROCESSING OVERVIEW

3.1.1. BRIEF DESCRIPTION

A brief overview of the main functions of the nominal CAL processing is given in this section. A detailed description is provided in section 3.2.

Two modes of calibrations are performed. The first one, CAL1, measures the point target response (PTR) of the altimeter corrected for the effects of the filter (Low Pass Filter) measured by the CAL2 calibration mode. The aim of the CAL1 sequence processing is to correct the PTR for the effects of the LPF and to compute the characteristics of the PTR. The aim of the CAL2 sequence processing is to normalize the LPF spectrum and to compute its characteristics (the mean LPF spectrum is computed on board, see RD6). In the following, the term “LPF spectrum” refers to the “unnormalized” filter measured on-board and the term “filter” refers to the LPF spectrum after normalization to correct the PTR.

The two modes of calibration are performed in Ku and C bands.

- For the CAL1 calibration sequence, the main parameters computed are:
  - The difference of internal travel between the transmission and the reference lines of the altimeter. This parameter is used to correct the distance measured between the satellite and the ocean surface (see ALT processing: "ALT_COR_RAN_01 - To compute the internal path correction").
  - The total power of the PTR that is used to compute the backscatter coefficient (see ALT processing: "ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation").
  - The width of the main lobe of the PTR and the maximum level of the secondary lobes of the PTR in order to detect the degradation of the measurements.
- For the CAL2 calibration sequence, the following parameters are computed after detection and removal of the leakage spikes:
  - The slopes of the right and left sides of the LPF spectrum.
  - The amplitude of the undulations for both sides of the LPF spectrum.
  - Then, the LPF spectrum is normalized and interpolated for use in the CAL1 processing to correct the waveforms (see ALT processing: "ALT_COR_WAV_01 - To correct the waveforms for the filtering effects").

The data obtained by the calibration processing will be used to look at the evolution of the instrument (“CMA expertise”). Some of the data obtained by the calibration processing are needed in the level 1b procedures. These data are written in a so-called “Long Term Monitoring” file which is an input of the level 1b procedures (see RD7).

3.1.2. LIST OF FUNCTIONS

A list of the functions of the nominal JASON-1 POSEIDON-2 CAL processing is given in **Figure 3**.

FUNCTION	CAL1	CAL2
ALT_CAL_LPF_01 - To detect the leakage spikes in the LPF spectrum		
ALT_CAL_LPF_02 - To correct the LPF spectrum for the leakage spikes		
ALT_CAL_LPF_03 - To determine the main features of the LPF spectrum		
ALT_CAL_LPF_04 - To normalize the LPF spectrum		
ALT_CAL_LPF_05 - To compute the coefficients of the LPF spectrum for mispointing angle estimation		
ALT_CAL_LPF_06 - To sample the filter at a new sampling frequency		
ALT_CAL_PTR_01 - To correct the Point Target Response		
ALT_CAL_PTR_02 - To compute the total power of the Point Target Response		
ALT_CAL_PTR_03 - To compute the characteristics of the main lobe of the PTR		
ALT_CAL_PTR_04 - To compute the characteristics of the secondary lobes of the PTR		
ALT_CAL_GEN_01 - To generate waveforms (1)		
ALT_CAL_GEN_02 - To apply calibrations (1)		
ALT_CAL_GEN_03 - To sample the signal and apply noise to it (1)		
ALT_CAL_GEN_04 - To estimate the altimetric parameters (1)		
ALT_CAL_GEN_05 - To check the parameters issued from the estimation (1)		

Figure 3: Functions of the nominal JASON-1 POSEIDON-2 CAL processing

(1) These algorithms are not specific to CAL1 or CAL2 processing. They are general procedures or procedures common to both calibration modes.

A "nominal” scenario for the on-board calibration is defined for routine instrument programming. All the calibration sequences performed with the nominal parameters of the calibration are processed in the altimeter level 1b processing. All the others are processed in the “expertise CMA”. Results obtained in the level 1b processing are written in an external "nominal calibration file". The results obtained with non-nominal calibration sequences (by the “expertise CMA”) are written in an external "non nominal calibration file" (see RD10 for the CAL Expertise processing).

The nominal calibration file is then used to produce an external file (the so-called Long Term Monitoring calibration file) containing the main results of the calibration data (considered as reference calibration data for a given period of the mission) that will be used to correct parameters of the OSDR, IGDR and GDR products. This last file gives the mean values of the calibration sequences on the day.

The functions listed below from “ALT_CAL_GEN_01 - To generate waveforms” to “ALT_CAL_GEN_05 - To check the parameters issued from the estimation” are used to estimate the altimetric parameters from a theoretical model, taking into account the altimeter calibration measurements. Then, these estimates are compared with the estimates computed with the calibration characteristic data (PTR and LPF spectrum) that are taken as references for a given period of the mission. These references are available in an external file that is updated depending on the evolution of the altimeter components. Finally, quality flags are issued. They will be checked within the Control algorithms.

Calibrations sequences are performed for both Ku and C bands. All the functions described below are assumed to be performed for Ku and (or) C band.

3.2. FUNCTIONS

A detailed description of the functions of the nominal JASON-1 CAL processing is given in this section.

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ALT_CAL_LPF_01 - To detect the leakage spikes in the LPF spectrum

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	Creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To detect the leakage spikes in the LPF spectrum.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data :
  - Number of samples in the LPF spectrum
  - Samples of the LPF spectrum
  - Interval (in frequency) between two samples of the LPF spectrum
  - Index associated with the zero frequency of the LPF spectrum
  - Likelihood flag of the LPF spectrum computed by the CCI
- Computed data : None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data
    - Half width of the analysis window (in frequency) to compute the DC component
  - Processing parameters
    - Standard deviation scale factor for outliers rejection

Output data

- Number of leakage spikes detected
- Values of the leakage spikes detected with respect to the mean

Mathematical statement

The aim of this algorithm is to detect the value and the position of the leakage spikes with a “kσ“ rejection algorithm (k is an integer).

ALGORITHM SPECIFICATION

Input data

- Number of samples in the LPF spectrum : Num_Val_LPF (/)
- Samples of the LPF spectrum : Val_LPF [0:Num_Val_LPF-1] (1)
- Interval (in frequency) between two samples of the LPF spectrum : T_LPF (Hz)
- Index associated with the zero frequency of the LPF spectrum : F0_LPF (/)
- Likelihood flag of the LPF spectrum : Flag_Val_LPF (/) (2)
- POSEIDON-2 instrumental characterization data:
  - Half width of the analysis window to compute the DC component : Width_Half_Band (Hz)
- Processing parameters:
  - Standard deviation scale factor for outliers rejection : N_Sig (/)

Output data

- Number of leakage spikes : Num_Leak_Spik (/)
- Values of the leakage spikes detected with respect to the mean : Val_Leak_Spik [0:Num_Val_LPF-1] (1)
- Execution status

Processing

The aim of this algorithm is to determine if there are any leakage spikes in the LPF spectrum and if so, to identify their number, position and value. The principle of this algorithm is to compute the mean and standard deviation values of the LPF spectrum and to compare the value of each sample of the LPF spectrum with the mean value taking into account the standard deviation (use of an outliers identification procedure).

If the LPF spectrum is declared "valid" (Flag_Val_LPF) then the following steps of the algorithm are implemented. If the validity flag is set to "invalid", then the output parameters are set to a default value.

Samples are chosen in a selected bandwidth [-Width_Half_Band, Width_Half_Band]. The frequency of the j^{th} sample (j from 0 to Num_Val_LPF-1) is computed by the following formula:

$$Freq\_LPF_j = (j - F0\_LPF) * T\_LPF$$

So the samples j are selected according to the next formula:

$$-Width\_Half\_Band \leq Freq\_LPF_j \leq Width\_Half\_Band$$

---

(1) FFT power unit

(2) 2 states : "valid" and "invalid"

The number of selected samples is given by:

$$Num\_Val\_Band = INT\left(\frac{2 * Width\_Half\_Band}{T\_LPF}\right) + 1 \quad (1)$$

- The mean (Mean_Val_LPF) and standard deviation (Sig_Val_LPF) values of the LPF spectrum in the bandwidth are computed using mechanism "GEN_MEC_COM_01 - Arithmetic averaging" (AD11) with the following inputs:
  - Number of samples of the LPF spectrum in the band : Num_Val_Band
  - Samples of the LPF spectrum in the band : Val_LPF_Band [0:Num_Val_Band-1] (1)

  Where: Val_LPF_Band [0:Num_Val_Band-1] = Val_LPF [I1:I2]

  With $I1 = F0\_LPF - INT\left(\frac{Width\_Half\_Band}{T\_LPF}\right)$ and $I2 = F0\_LPF + INT\left(\frac{Width\_Half\_Band}{T\_LPF}\right)$

- Detection of the leakage spikes with a N_Sig outliers rejection criteria:
  - $Val\_Leak\_Spik_j = Val\_LPF_j - Mean\_Val\_LPF$ (j goes from 0 to Num_Val_LPF-1) (2)

  For each sample j used in the estimation of the mean value, the following test is performed:

  - If $Val\_Leak\_Spik_j < N\_Sig * Sig\_Val\_LPF$ then $Val\_Leak\_Spik_j = 0$ (3)

    and the next sample of the LPF spectrum is processed (j+1).

    Else $Val\_Leak\_Spik_j$ is unchanged and the number of leakage spikes is incremented (the parameter Num_Leak_Spik must have been initialized to 0).

    $$Num\_Leak\_Spik = Num\_Leak\_Spik + 1 \quad (4)$$

    End

  End

ACCURACY

N/A

COMMENTS

All samples outside the selected bandwidth are treated as leakage spikes, although the number of leakage spikes (Num_Leak_Spik) counts only those leakage spikes found within the bandwidth.

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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31401 TOULOUSE CEDEX 4

ALT_CAL_LPF_02 - To correct the LPF spectrum for the leakage spikes

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

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Algorithm change record	Creation	Date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To correct the LPF spectrum for the leakage spikes.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data :
  - Number of samples in the LPF spectrum
  - Likelihood flag of the LPF spectrum computed by the CCI
  - Samples of the LPF spectrum
- Computed data :
  - From "ALT_CAL_LPF_01 - To detect the leakage spikes in the LPF spectrum"
    - Number of leakage spikes in the LPF spectrum
    - Values of the leakage spikes detected with respect to the mean
- Static auxiliary data : None

Output data

- Samples of the LPF spectrum corrected for the leakage spikes

Mathematical statement

The aim of this algorithm is to correct the LPF spectrum by subtracting the leakage spikes.

ALGORITHM SPECIFICATION

Input data

- Number of samples in the LPF spectrum : Num_Val_LPF (/)
- Samples of the LPF spectrum : Val_LPF [0:Num_Val_LPF-1] (1)
- Number of the leakage spikes in the LPF spectrum : Num_Leak_Spik (/)
- Values of the leakage spikes detected with respect to the mean : Val_Leak_Spik [0:Num_Val_LPF-1] (1)
- Likelihood flag of the LPF spectrum : Flag_Val_LPF (/) (2)

Output data

- Samples of the LPF spectrum corrected for the leakage spikes : Cor_Val_LPF [0:Num_Val_LPF-1] (1)
- Execution status

Processing

The aim of this algorithm is to correct the LPF spectrum by subtraction of the leakage spikes.

$$Cor\_Val\_LPF_j = Val\_LPF_j - Val\_Leak\_Spik_j \quad \text{with j from 0 to Num\_Val\_LPF-1} \qquad (1)$$

This processing must be applied only when Num_Leak_Spik is greater than 0 (if Num_Leak_Spik=0, $Val\_Leak\_Spik_j$=0 and the subtraction is useless) and only if the Flag_Val_LPF is declared "valid". If this parameter is set to "invalid", there is no correction to apply.

ACCURACY

N/A

COMMENTS

None

(1) FFT power unit

(2) 2 states : "valid" and "invalid"

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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ALT_CAL_LPF_03 - To determine the main features of the LPF spectrum

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	Date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the main features of each side (right: frequencies > 0; Left: frequencies < 0) of the LPF spectrum given by the CAL2 calibration sequence (see RD6) and to control them with respect to predefined values.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data :
  - Number of samples in the LPF spectrum
  - Interval (in frequency) between two samples of the LPF spectrum
  - Index associated with the zero frequency of the LPF spectrum
  - Likelihood flag of the LPF spectrum computed by the CCI
- Computed data :
  - From "ALT_CAL_LPF_02 - To correct the LPF spectrum for the leakage spikes"
    - Samples of the LPF spectrum corrected for the leakage spikes
- Static auxiliary data :
  - POSEIDON-2 instrumental characterization data:
    - Half width of the analysis window to compute the DC component: $\Delta\nu$
    - Predefined values of the main features (values that have been obtained by the ground measurement of the filter or by the on-board filter taken as the reference filter for the mission)
  - Processing parameters
    - Thresholds percentages

Output data

- Mean values of the right and left sides of the LPF spectrum and associated flags
- Standard deviation of the right and left sides of the LPF spectrum

- Differences between the minimum and maximum values in the right and left sides of the LPF spectrum and associated flags
- Slopes of the linear regressions for the right and left sides of the LPF spectrum and associated flags
- Standard deviations about the slopes of the linear regression for the right and left sides of the LPF spectrum

Mathematical statement

For each side of the LPF spectrum, the following features are computed:

- Mean and standard deviation of the samples
- Difference between the values of the maximum sample and the minimum sample
- Slope

These features are computed for the frequency range [-Δν kHz, 0 kHz[and]0 kHz, Δν kHz]. The minimum and maximum values of each side of the LPF spectrum are obtained and their difference is computed. Computations are performed with the values of the samples in dB.

The slope of each side of the LPF spectrum is obtained by using a linear regression.

The slopes and associated standard deviation about the slopes are given in dB/Hz.

The parameters given by the processing of the CAL2 calibration sequence that have to be verified are:

- The mean values of each of the left and right sides of the LPF spectrum
- The peak to peak amplitudes in the left and right sides of the LPF spectrum
- The slopes of the left and right sides of the LPF spectrum

These parameters are compared with the parameters issued from the LPF spectrum taken as references to compute the tables of correction (see Appendix 1 : Modeled instrumental corrections). Five flags are obtained:

- One flag for the mean of the left side of the LPF spectrum
- One flag for the mean of the right side of the LPF spectrum
- One flag for the peak to peak amplitude in the left side of the LPF spectrum
- One flag for the peak to peak amplitude in the right side of the LPF spectrum
- One flag for the slope of the left side of the LPF spectrum
- One flag for the slope of the right side of the LPF spectrum
- One flag for the std of the left mean of the LPF spectrum
- One flag for the std of the right mean of the LPF spectrum
- One flag for the std of the left slope of the LPF spectrum
- One flag for the std of the right slope of the LPF spectrum

ALGORITHM SPECIFICATION

Input data

- Number of samples in the LPF spectrum : Num_Val_LPF (/)
- Samples of the LPF spectrum corrected for the leakage spikes : Cor_Val_LPF [0:Num_Val_LPF-1] [(1)]
- Interval (in frequency) between two samples of the LPF spectrum : T_LPF (Hz)
- Index associated with the zero frequency of the LPF spectrum : F0_LPF (/)
- Half width of the analysis window to compute the DC component : Width_Half_Band (Hz)
- Likelihood flag of the LPF spectrum : Flag_Val_LPF (/) [(2)]
- Predefined mean value of the left side : Pre_Left_Mean (dB)
- Predefined mean value of the right side : Pre_Right_Mean (dB)
- Threshold percentage for the mean value : Thres_Mean (/)
- Predefined standard deviation value of the left side : Pre_Left_Std (dB)
- Predefined standard deviation value of the right side : Pre_Right_Std (dB)
- Threshold percentage for the standard deviation value : Thres_Std (/)
- Predefined difference between min and max values for the left side : Pre_Left_Diff (dB)
- Predefined difference between min and max values for the right side : Pre_Right_Diff (dB)
- Threshold percentage for the difference value : Thres_Diff (/)
- Predefined slope for the left side : Pre_Left_Slope (dB/Hz)
- Predefined slope for the right side : Pre_Right_Slope (dB/Hz)
- Threshold percentage for the slope value : Thres_Slope (/)
- Predefined standard deviation about the slope for the left side : Pre_Left_Std_Slope (dB)
- Predefined standard deviation about the slope for the right side : Pre_Right_Std_Slope (dB)
- Threshold percentage for the standard deviation of the slope : Thres_Std_Slope (/)

Output data

- Characteristics of the left side of the LPF spectrum and validity flags:
  - Mean value : Left_Mean_Val_LPF (dB)
  - Associated flag : Left_Mean_Flag_LPF (/)[(2)]
  - Standard deviation : Left_Std_Val_LPF (dB)

---

(1) FFT power unit

(2) 2 states : “valid” and “invalid”

- Associated flag : Left_Std_Flag_LPF (/) (2)
- Difference between the minimum and maximum values : Left_Diff_Val_LPF (dB)
- Associated flag : Left_Diff_Flag_LPF (/) (2)
- Slope of the linear regression : Left_Slope_Val_LPF (dB/Hz)
- Associated flag : Left_Slope_Flag_LPF (/) (2)
- Standard deviation value about the slope : Left_Std_Slope_Val_LPF (dB)
- Associated flag : Left_Std_Slope_Flag_LPF (/) (2)

- Characteristics of the right side of the LPF spectrum and validity flags:
  - Mean value : Right_Mean_Val_LPF (dB)
  - Associated flag : Right_Mean_Flag_LPF (/)(2)
  - Standard deviation : Right_Std_Val_LPF (dB)
  - Associated flag : Right_Std_Flag_LPF (/)(2)
  - Difference between the minimum and maximum values : Right_Diff_Val_LPF (dB)
  - Associated flag : Right_Diff_Flag_LPF (/)(2)
  - Slope of the linear regression : Right_Slope_Val_LPF (dB/Hz)
  - Associated flag : Right_Slope_Flag_LPF (/)(2)
  - Standard deviation value about the slope : Right_Std_Slope_Val_LPF (dB)
  - Associated flag : Right_Std_Slope_Flag_LPF (/)(2)
- Execution status

Processing

If Flag_Val_LPF is set to "invalid" then the output parameters are set to a default value.

Else (LPF validity flag (Flag_Val_LPF) is set to "valid") the following procedure is implemented.

For each side of the LPF spectrum, the following features are computed:

- Mean and standard deviation of the samples
- Difference between the values of the maximum sample and the minimum sample
- Slope and the standart deviation of the samples about the slopes

- These characteristics are computed on a given bandwidth: [-Width_Half_Band, 0[for the left side of the LPF spectrum and]0;Width_Half_Band] for the right side of the LPF spectrum.

- First of all, the LPF spectrum is converted in dB according to:

$$Val\_LPF\_DB_j = 10 * \log_{10}(Cor\_Val\_LPF_j) \quad (1)$$

where j goes from 0 to (Num_Val_LPF-1)

- Determination of the frequency positions of the samples

The frequency of the j^{th} sample of the LPF spectrum is computed by:

$$Freq\_LPF_j = (j - F0\_LPF) * T\_LPF \quad (2)$$

So for the left side of the LPF spectrum, samples used to compute the characteristics are samples j that satisfy:

$$-Width\_Half\_Band \le Freq\_LPF_j < 0 \quad (3)$$

and for the right side of the LPF spectrum, samples used to compute the characteristics are samples j that satisfy:

$$0 < Freq\_LPF_j \le Width\_Half\_Band \quad (4)$$

The number of selected samples is given by (X means Right or Left):

$$Num\_Val\_X = INT\left(\frac{Width\_Half\_Band}{T\_LPF}\right) \quad (5)$$

- The mean (X_Mean_Val_LPF) and standard deviation (X_Std_Val_LPF) values are computed for each side of the LPF spectrum (X must be considered as Right or Left), using mechanism “GEN_MEC_COM_01 - Arithmetic averaging” (AD11) with the following inputs:
  - Number of samples of the LPF spectrum in the X side of the spectrum : Num_Val_X
  - Samples of the LPF spectrum in the X side of the spectrum : Val_LPF_DB_X [0:Num_Val_X-1]
- The minimum (Min_X_Val) and maximum (Max_X_Val) of each side of the LPF spectrum are also outputs of this mechanism and their difference is computed.

$$Left\_Diff\_Val\_LPF = Max\_Left\_Val - Min\_Left\_Val \quad (6)$$

and

$$Right\_Diff\_Val\_LPF = Max\_Right\_Val - Min\_Right\_Val \quad (7)$$

- Then, the slope of each side of the LPF spectrum is computed using mechanism “GEN_MEC_COM_02 - Linear regression / Least square method” (AD11) with the following inputs:
  - Number of points of the regression : Num_Val_X (/)
  - Set of ordinates : Val_LPF_DB_X [0:Num_Val_X-1] (dB)
  - Set of corresponding abscissa : Freq_X_LPF [0:Num_Val_X-1] (Hz)

The outputs of this mechanism are:

- Order 1 coefficient (slope) : Slope_Val_LPF (dB/Hz)
- Order 0 coefficient : C0 (dB)
- Standard deviation with respect to the linear model : Std_Slope_Val_LPF (dB)

The 2 parameters Slope_Val_LPF and Std_Slope_Val_LPF must be prefixed by “Right” or “Left” depending of the side of the LPF processed.

The parameters given by the processing of the CAL2 calibration sequence that have to be verified are:

- The mean values of each of the left and right sides of the LPF spectrum
- The standard deviation values of each of the left and right sides of the LPF spectrum
- The amplitudes of oscillations in the left and right sides of the LPF spectrum
- The slopes of the left and right sides of the LPF spectrum
- The standard deviation about the slopes of the left and right sides of the LPF spectrum

All the parameters that have been computed must be compared with the parameters issued from the LPF spectrum taken as references to compute the tables of correction (see Appendix 1) and likelihood flags are issued.

The procedure used to check these parameters is equivalent as the procedure described in the “ALT_CAL_GEN_05 - To check the parameters issued from the estimation”.

The procedure used to check the main features of the LPF spectrum is the mechanism (AD11) “GEN_MEC_QUA_04 - Check of a parameter versus a reference value” with the following inputs:

- Parameter to be checked : X
- Reference value of the parameter : X_Ref (same unit as X)
- Threshold percentage : Thres_X (/)

The output is the validity flag of the parameter Flag_X (2 states)

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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ALT_CAL_LPF_04 - To normalize the LPF spectrum

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the normalized samples of the LPF spectrum.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of samples in the LPF spectrum
  - Interval (in frequency) between two samples of the LPF spectrum
  - Index associated with the zero frequency sample of the LPF spectrum
  - Likelihood flag of the LPF spectrum computed by the CCI
- Computed data:
  - From "ALT_CAL_LPF_02 - To correct the LPF spectrum for the leakage spikes":
    - Samples of the LPF spectrum corrected for the leakage spikes
- Static auxiliary data: None

Output data

- Normalized values of the samples of the LPF spectrum
- Localization (in frequency) of the max value of the LPF spectrum

Mathematical statement

The normalized values (between 0 and 1) are computed by dividing the values of the samples of the LPF spectrum by the maximum value of the LPF samples:

$$Vnorm_j = \frac{V_j}{\max_j \{V_j\}} \quad (1)$$

The normalized LPF spectrum is also called the filter.

ALGORITHM SPECIFICATION

Input data

- Number of samples in the LPF spectrum : Num_Val_LPF (/)
- Samples of the LPF spectrum corrected for the leakage spikes : Cor_Val_LPF [0:Num_Val_LPF-1] (1)
- Interval in frequency between two samples of the LPF spectrum : T_LPF (Hz)
- Index associated with the zero frequency sample of the LPF spectrum : F0_LPF (/)
- Likelihood flag of the LPF spectrum computed by the CCI : Flag_Val_LPF (/) (2)

Output data

- Normalized values of the samples of the LPF spectrum (= values of the filter) : Filter [0:Num_Val_LPF-1] (/)
- Localization (in frequency) of the max value of the LPF spectrum : Freq_Max_Val (Hz)
- Execution status

Processing

The aim of this algorithm is to identify the frequency of the max value of the LPF spectrum and to normalize the LPF spectrum by dividing the samples by this max value.

If Flag_Val_LPF is set to "invalid", the output parameters are set to a default value.

Else the following procedure is implemented.

The frequency of the maximum sample of the LPF spectrum is obtained by:

$$\mathrm{Freq\_Max\_Val} = (k - \mathrm{F0\_LPF}) * \mathrm{T\_LPF} \quad (1)$$

where k is the index associated with the max value of the LPF spectrum.

$$\mathrm{Filter}_j = \frac{\mathrm{Cor\_Val\_LPF}_j}{\mathrm{Cor\_Val\_LPF}_k} \quad (2)$$

where j goes from 0 to (Num_Val_LPF-1)

ACCURACY

N/A

---

(1) FFT power unit

(2) 2 states : "valid" and "invalid"

COMMENTS

None

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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ALT_CAL_LPF_05 - To compute the coefficients of the LPF spectrum for mispointing angle estimation

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT	CNES	

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

None

FUNCTION

To compute the 3 coefficients of the LPF spectrum that are used in the level 1B ALT processing (factors representing the mean filter effect in three windows, see "ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates").

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

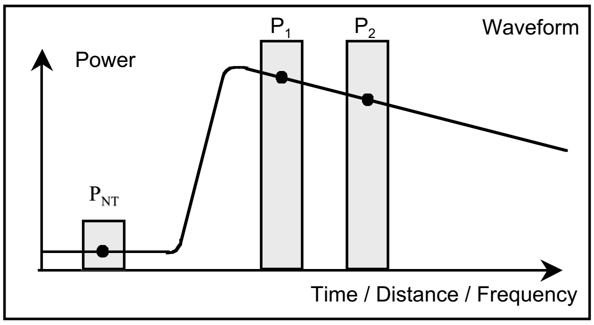
- Product data:
  - Interval in frequency between two samples of the LPF spectrum
  - Index associated with the zero frequency sample of the LPF spectrum
  - Likelihood flag of the LPF spectrum computed by the CCI
  - Number of samples in the normalized LPF spectrum
- Computed data:
  - From "ALT_CAL_LPF_04 - To normalize the LPF spectrum":
    - Normalized values of the samples of the LPF spectrum
- Static auxiliary data:
  - Processing parameters
    - Bandwidth (in frequency) used to compute the energy of the thermal noise (P_{NT})
    - Bandwidth (in frequency) used to compute the energy of the first gate on the trailing edge (P_1)
    - Bandwidth (in frequency) used to compute the energy of the second gate on the trailing edge (P_2)
    - Frequency of the beginning of the gate used to compute P_{NT}
    - Frequency of the beginning of the gate used to compute P_1
    - Frequency of the beginning of the gate used to compute P_2

Output data

- Values of the three factors P_{NT}, P_1 and P_2

Mathematical statement

The mean value of the filter is computed in the gates used to estimate the thermal noise and the two trailing edge energies.



ALGORITHM SPECIFICATION

Input data

- Number of samples in the filter (=Num_Val_LPF) : Num_Val_Filt (/)
- Samples of the filter : Filter[0:Num_Val_Filt-1] (/)
- Interval in frequency between two samples of the LPF spectrum : T_LPF (Hz)
- Index associated with the zero frequency sample of the LPF spectrum : F0_LPF (/)
- Bandwidth used to compute the energy of the thermal noise (P_{NT}) : Band_PNT (Hz)
- Bandwidth used to compute the energy of the first gate on the trailing edge (P_1) : Band_P1 (Hz)
- Bandwidth used to compute the energy of the second gate on the trailing edge (P_2) : Band_P2 (Hz)
- Frequency of the beginning of the gate used to compute P_{NT} : F1_PNT (Hz)
- Frequency of the beginning of the gate used to compute P_1 : F1_P1 (Hz)
- Frequency of the beginning of the gate used to compute P_2 : F1_P2 (Hz)
- Likelihood flag of the LPF spectrum : Flag_Val_LPF (/) (1)

(1) 2 states : “valid” and “invalid”

Output data

- Value of the factor P_{NT} : Mean_PNT (/)
- Standard deviation of the factor P_{NT} : Std_PNT (/)
- Value of the factor P_1 : Mean_P1 (/)
- Standard deviation of the factor P_1 : Std_P1 (/)
- Value of the factor P_2 : Mean_P2 (/)
- Standard deviation of the factor P_2 : Std_P2 (/)
- Execution status

Processing

This algorithm is aimed at computing the energy of the three bands used to compute the mispointing angle in the level 1B ALT processing.

If Flag_Val_LPF is set to "invalid", the output parameters are set to a default value.

Else the following procedure is implemented.

The three bands are identified by the frequency of the beginning of the band and their widths. So, the first step of the algorithm consists in identifying the samples of the filter for each band of energy.

- Determination of the frequency positions of all the samples of the filter

  The frequency of the j^th sample of the filter is computed by the following formula:

  $$\mathrm{Freq\_LPF}_j = (j - \mathrm{F0\_LPF}) * \mathrm{T\_LPF} \quad (1)$$

  So for the thermal noise band, samples used to compute the characteristics are samples j that satisfy:

  $$\mathrm{F1\_PNT} \leq \mathrm{Freq\_LPF}_j \leq \mathrm{F1\_PNT} + \mathrm{Band\_PNT} \quad (2)$$

  For the first band on the trailing edge, samples used to compute the characteristics are samples j that satisfy:

  $$\mathrm{F1\_P1} \leq \mathrm{Freq\_LPF}_j \leq \mathrm{F1\_P1} + \mathrm{Band\_P1} \quad (3)$$

  For the second band on the trailing edge, samples used to compute the characteristics are samples j that satisfy:

  $$\mathrm{F1\_P2} \leq \mathrm{Freq\_LPF}_j \leq \mathrm{F1\_P2} + \mathrm{Band\_P2} \quad (4)$$

  The numbers of selected samples in each band are: Num_Val_PNT, Num_Val_P1 and Num_Val_P2

- The mean (Mean_PNT) and standard deviation (Std_PNT) values of the thermal noise band are computed using mechanism "GEN_MEC_COM_01 - Arithmetic averaging" (AD11) with the following inputs:
  - Number of samples of the thermal noise band : Num_Val_PNT
  - Samples of the filter in the thermal noise band : Filter_j

- The mean (Mean_P1) and standard deviation (Std_P1) values of the P1 band are computed using mechanism " GEN_MEC_COM_01 - Arithmetic averaging" (AD11) with the following inputs:
  - Number of samples of the P1 band : Num_Val_P1
  - Samples of the filter in the P1 band : $Filter_j$
- The mean (Mean_P2) and standard deviation (Std_P2) values of the P2 band are computed using mechanism " GEN_MEC_COM_01 - Arithmetic averaging" (AD11) with the following inputs:
  - Number of samples of the P2 band : Num_Val_P2
  - Samples of the filter in the P2 band : $Filter_j$

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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ALT_CAL_LPF_06 - To sample the filter at a new sampling frequency

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

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	CCM			

HERITAGE

None

FUNCTION

To sample the filter at a new sampling frequency.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of samples of the filter array
  - Interval (in frequency) between two samples of the filter array
  - Index associated with the zero frequency of the filter array
  - Likelihood flag of the LPF spectrum
- Computed data:
  - From "ALT_CAL_LPF_04 - To normalize the LPF spectrum":
    - Samples of the filter array
- Static auxiliary data:
  - Processing parameters
    - Interval (in frequency) between two samples of the output filter array (equivalent to the interval (in freq.) between two points of the nominal PTR)

Output data

- Samples of the filter at the new sampling frequency
- Index associated with the zero frequency of the output filter array
- Number of samples of the output filter array
- Likelihood flag of the filter

Mathematical statement

This algorithm is aimed at sampling the input filter array at a new sampling frequency.

ALGORITHM SPECIFICATION

Input data

- Number of samples of the input filter : Num_Val_In_Filter (/)
- Interval (in freq.) between two samples of the input filter : T_In_Filter (Hz)
- Index associated with the zero frequency of the input filter : F0_In_Filter (/)
- Samples of the input filter : Val_In_Filter [0:Num_Val_In_Filter-1]
- Interval (in freq.) between two samples of the output filter : T_Out_Filter (Hz)
- Likelihood flag of the filter : Flag_Val_LPF (/) (1)

Output data

- Number of samples of the output filter : Num_Val_Out_Filter (/)
- Samples of the output filter : Val_Out_Filter [0:Num_Val_Out_Filter-1] (/)
- Index associated with the zero frequency of the output filter : F0_Out_Filter (/)
- Likelihood flag of the interpolated filter : Flag_Val_Filter (/) (1)
- Execution status

Processing

If the LPF validity flag (Flag_Val_LPF) is set to “valid”, then the following procedure is performed.

Else (Flag_Val_LPF set to “invalid”) the output parameters are set to a default value and “Flag_Val_Filter” is set to “invalid”.

This algorithm is aimed at interpolating or sub-sampling the input filter array at a new sampling frequency

- If T_In_Filter > T_Out_Filter : interpolation

  The input filter can be interpolated if its sampling frequency is smaller than the expected sampling frequency of the output filter.

  The interpolation is performed using the mechanism (AD11) “GEN_MEC_INT_05 – Interpolation of an array at a new sampling frequency” with the following entries:

  – Number of samples of the input array : Num_Val_In_Filter (/)

(1) 2 states : “valid” and “invalid”

- Interval (in frequency) between two samples of the input array : T_In_Filter (Hz)
- Index associated with the zero frequency of the input array : F0_In_Filter (/)
- Samples of the input array : Val_In_Filter [0:Num_Val_In_Filter-1] (/)
- Interval (in frequency) between two samples of the output array : T_Out_Filter (Hz)

The outputs of the mechanism are:

- Number of samples of the output array : Num_Val_Out_Filter (/)
- Samples of the output array : Val_Out_Filter [0:Num_Val_Out_Filter-1] [1]
- Index associated with the zero frequency of the output array : F0_Out_Filter (/)

- if $T\_In\_Filter = T\_Out\_Filter$ then

– $Num\_Val\_Out\_Filter = Num\_Val\_In\_Filter$ (1)

– $Val\_Out\_Filter_j = Val\_In\_Filter_j$ for j from 0 to Num_Val_In_Filter-1 (2)

– $F0\_Out\_Filter = F0\_In\_Filter$ (3)

- If T_In_Filter < T_Out_Filter : <u>sub-sampling</u>

The input filter can be sub-sampled if its sampling frequency is larger than the output sampling frequency.

– $$C = NINT\left[\frac{T\_Out\_Filter}{T\_In\_Filter}\right] \quad (4)$$

– $$Num\_Val\_Out\_Filter = NINT\left[\frac{Num\_Val\_In\_Filter}{C}\right] \quad (5)$$

– $Val\_Out\_Filter_j = Val\_In\_Filter_{j*C}$ for j=0 to Num_Val_Out_Filter (6)

– $$F0\_Out\_Filter = NINT\left[\frac{F0\_In\_Filter}{C}\right] \quad (7)$$

NINT(x) represents the function which rounds x to the nearest integer value

ACCURACY

N/A

COMMENTS

None

---

[1] 2 states “valid” and “invalid”

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_CAL_PTR_01 - To correct the Point Target Response

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

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Algorithm change record	Creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To correct the point target response (PTR) for the effects of the filter.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - On board time-tag associated with the CAL1 sequence
  - On board time-tag associated with the CAL2 sequence
  - Number of samples of the point target response
  - Samples of the PTR
  - Index associated with the zero frequency of the PTR
  - Likelihood flag of the PTR computed by the CCI
- Computed data:
  - From "ALT_CAL_LPF_06 - To sample the filter at a new sampling frequency":
    - Samples of the filter
    - Likelihood flag of the filter
    - Number of samples of the filter
    - Index associated with the zero frequency of the filter
- Static auxiliary data:
  - Processing parameters:
    - Maximum value of the time interval between a CAL1 and a CAL2 calibration sequence
  - POSEIDON-2 instrumental characterization data
    - Values of the filter taken as reference for the mission

Output data

- Samples of the PTR corrected with the filter
- Validity flag of the corrected PTR

Mathematical statement

The samples of the PTR are corrected for the low pass filter effects by dividing all of them by the value of the filter at the same frequency. When the value of the filter equals 0, the value of the corrected point target response is set to 0.

The PTR to process is issued from a management algorithm which computes the power of the PTR from the (I,Q) values.

The filter used to correct the PTR is chosen according to the next procedure (in a management algorithm):

- If a measurement of the filter has been performed in the interval of time [Date_Cal1 – Time_Max, Date_Cal1 + Time_Max] and if the validity flag of the filter is set to "valid" then this filter is used to compute the correction of the PTR.
- If there is no filter measurement in this interval of time or if the validity flag of the filter is set to “invalid”, then a filter issued from the POSEIDON2 instrumental characterization data is used. This filter is considered as the mean filter of the instrument for the mission. It is updated depending on the evolution of the altimeter components.

Prior to constructing the PTR, we make sure that the PTR to process is correct. This is performed by checking a likelihood flag of the PTR. If the PTR is not correct, the next CAL1 calibration sequence is processed.

ALGORITHM SPECIFICATION

Input data

- Number of samples of the PTR : Num_Val_PTR (/)
- Samples of the point target response : Val_PTR [0:Num_Val_PTR-1] (1)
- Index associated with the zero frequency of the PTR : F0_PTR (/)
- Likelihood flag of the PTR : Flag_Val_PTR (/)(2)
- Likelihood flag of the selected filter : Flag_Val_Sel_Filter (/) (2)
- Number of samples of the selected filter : Num_Val_Sel_Filter (/)
- Index associated with the zero frequency of the selected filter : F0_Sel_Filter (/)

(1) : FFT power unit

(2) 2 states : “valid” and “invalid”

- Samples of the selected filter : Val_Sel_Filter [0:Num_Val_Sel_Filter-1] (/)

Output data

- Samples of the PTR corrected with the filter : Val_Cor_PTR [0:Num_Val_PTR-1] (1)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/) (2)
- Execution status

Processing

The samples of the PTR are corrected for the filter effects by dividing all of them by the value of the filter at the same frequency. When the value of the filter equals 0, the value of the corrected point target response is set to 0.

Prior to constructing the PTR, we make sure that the PTR to process is correct. This is performed by checking the likelihood flag Flag_Val_PTR that must be set to "valid". In this case, the procedure described below is implemented. If Flag_Val_PTR is set to "invalid" then the output parameters are set to a default value, the validity flag of the corrected PTR is set to invalid and the following procedure is not performed.

After re-sampling of the filter, the index associated with the zero frequency of the filter equals the index of the zero frequency of the PTR (and Num_Val_PTR=Num_Val_Filter after re-sampling of the filter) and it is possible to correct the PTR. The PTR is corrected with the filter measured if the spent time between the measurement of the filter and the measurement of the PTR is shorter than a maximum interval of time permitted. The choice has been done by a management algorithm.

The samples of the PTR are corrected for the effects of the filter according to :

If Flag_Val_Sel_Filter is set to "valid" and F0_PTR = F0_Sel_Filter

$$Val\_Cor\_PTR_j = \frac{Val\_PTR_j}{Val\_Sel\_Filter_j} \quad \text{if} \quad Val\_Sel\_Filter_j \neq 0 \tag{1a}$$

$$Val\_Cor\_PTR_j = 0 \quad \text{if} \quad Val\_Sel\_Filter_j = 0 \tag{1b}$$

with j : index of the samples of the PTR from 0 to (Num_Val_PTR-1=Num_Val_Sel_Filter-1)

Then, the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to valid.

ACCURACY

N/A

COMMENTS

The filter used to correct the PTR must have been generated with the same altimeter configuration characteristics. So if the PTR to correct is nominal (for all configuration parameters given in the TC), then the filter must also have been obtained with nominal configuration parameters. If there is no measurement of the filter for these nominal parameters, the default nominal filter must be taken into account.

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_CAL_PTR_02 - To compute the total power of the Point Target Response

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute and check the total power enclosed in the PTR.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Interval in frequency between two samples of the PTR
  - Index associated with the zero frequency sample of the PTR
  - Number of samples of the PTR
- Computed data:
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Samples of the point target response corrected for the filter effects
    - Validity flag of the corrected PTR
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Reference of the total power of the PTR
  - Processing parameters
    - Threshold percentage on the estimation of the power of the PTR
    - Half width of the analysis window in which the total power is computed

Output data

- Total power of the point target response and associated flag

Mathematical statement

The total power enclosed in the spectrum of the PTR is obtained by summing the values of the samples of the point target response:

$$P = \sum_j X_j \qquad (1)$$

where Xj is the sample of the PTR in the analysis window.

This parameter has to be compared with the total power computed from the PTR that was used to compute the tables of correction (see Appendix 1). One flag for the total power of the PTR is output.

ALGORITHM SPECIFICATION

Input data

- Number of samples of the PTR : Num_Val_PTR (/)
- Samples of the PTR corrected for the effects of the filter :Val_Cor_PTR [0:Num_Val_PTR-1] (1)
- Index associated with the zero frequency of the PTR : F0_PTR (/)
- Interval in frequency between two samples of the PTR : T_PTR (Hz)
- Half width of the analysis window in which the total power is computed : Half_Band_PTR (Hz)
- Threshold percentage on the estimation of the power of the PTR : Thres_Power_PTR (/)
- Reference of the total power of the PTR : Tot_PTR_Ref (1)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/)(2)

Output data

- Total power of the point target response : Tot_Power (1)
- Associated flag : Flag_Tot_Power (/)
- Execution status

Processing

- If the validity flag of the corrected PTR, Flag_Val_Cor_PTR, is set to valid then the following procedure is applied :

---

(1) : FFT power unit

(2) 2 states "valid" and "invalid"

The aim of this algorithm is to compute the total power of the PTR according to:

$$\mathrm{Tot\_Power} = \sum_j \mathrm{Val\_Cor\_PTR}_j \quad (1)$$

where j is the index of the samples in the bandwidth [-Half_Band_PTR, Half_Band_PTR]

The frequency of the j^{th} sample of the PTR is computed by:

$$\mathrm{Freq\_PTR}_j = (j - \mathrm{F0\_PTR}) * \mathrm{T\_PTR} \quad (2)$$

So the selected samples of the PTR are selected by:

$$-\mathrm{Half\_Band\_PTR} \le \mathrm{Freq\_PTR}_j \le \mathrm{Half\_Band\_PTR} \quad (3)$$

The Tot_Power parameter has to be compared with the total power computed from the PTR that was used to compute the tables of correction (see Appendix 1). One quality flag for the total power of the PTR is output (Flag_Tot_Power).

The procedure used to check this parameter is the mechanism described in (AD11) "GEN_MEC_QUA_04 – Check of a parameter versus a reference value" with the following input:

- Parameter to be checked : Tot_Power (FFT power unit)
- Reference value of the parameter : Tot_PTR_Ref (FFT power unit)
- Threshold percentage : Thres_Power_PTR (/)

The output is the validity flag of the parameter Flag_X (2 states)

- Else the total power of the PTR is not computed and the output parameters are set to a default value and Flag_Tot_Power is set to "invalid".

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_CAL_PTR_03 - To compute the characteristics of the main lobe of the PTR

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	Creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute and check some characteristics of the main lobe of the point target response.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of samples of the PTR
  - Index associated with the zero frequency of the PTR
  - Interval (in frequency) between two samples of the PTR
- Computed data:
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Samples of the point target response corrected for the effects of the low pass filter
    - Validity flag of the corrected PTR
  - From "ALT_CAL_PTR_02 - To compute the total power of the Point Target Response":
    - Total power of the point target response
- Static auxiliary data:
  - Processing parameters:
    - Order of the polynomial to fit to the main lobe
    - Number of points used for the polynomial regression
    - Half width of the analysis window (in frequency)
  - POSEIDON-2 instrumental characterization data:
    - Bandwidth of the signal
    - Pulse duration
    - Reference values of the parameters to be checked

- Universal constants:
  - Light velocity

Output data

- Maximum value of the point target response
- Frequency associated with the maximum of the point target response
- Difference of travel between the transmission and the reference lines and associated flag
- Width of the main lobe of the point target response at -3 dB and associated flag
- Position of the median of the PTR

Mathematical statement

The characteristics of the main lobe of the point target response (PTR) that must be determined are:

- the position (frequency) of the maximum and its value
- the half power width of the main lobe
- the difference of travel between the transmission and the reference lines

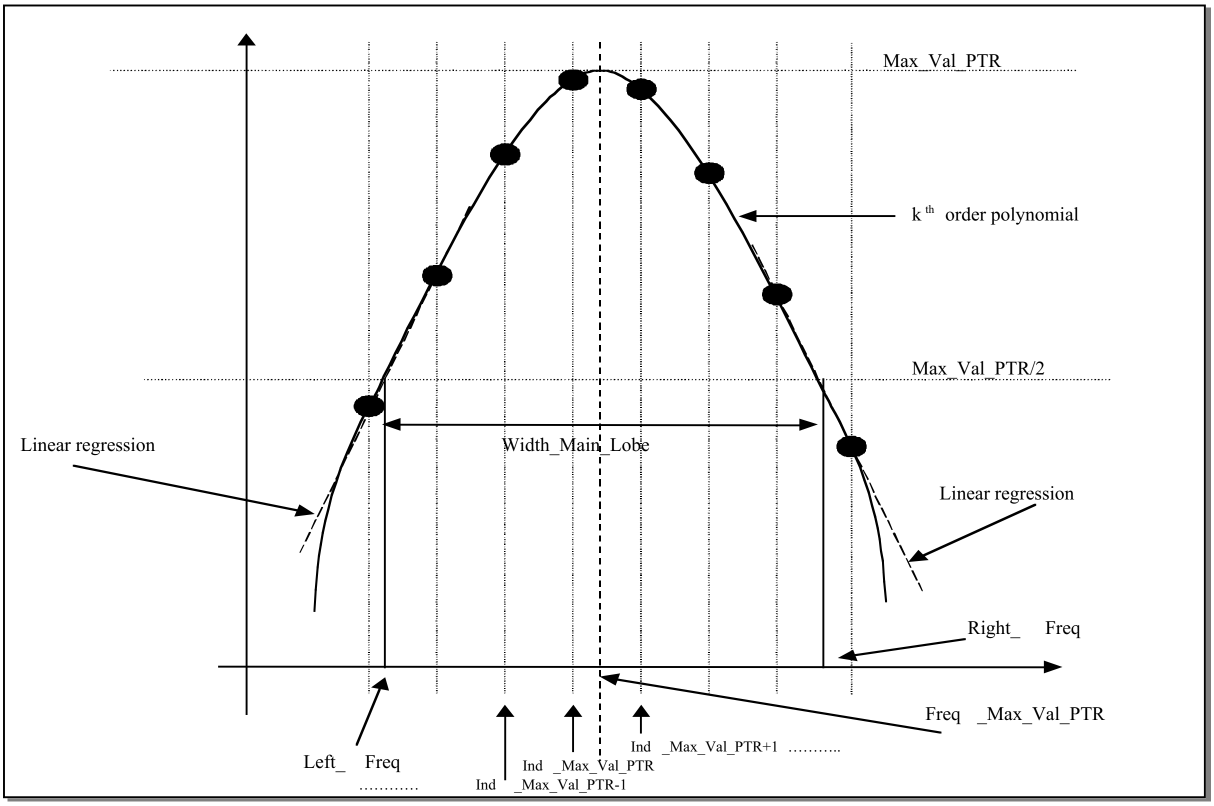
The precise position of the maximum in the main lobe is derived according to the following procedure:

1) Search of the sample around the maximum value of the PTR
2) Selection of N samples around the maximum value (N/2 samples on the left, N/2 samples on the right, N<7)
3) Computation of the coefficients of a k^{th} order polynomial that fits these (N+1) samples (k <=6).
4) Computation of the derivative function of this polynomial
5) Search of the position of the roots of this derivative function

Once the precise position of the maximum of the main lobe is obtained, the value of this maximum is recomputed by evaluating the k^{th} order polynomial at the position of the maximum of the main lobe.

The half power width is given by the following procedure:

1) Computation of the power which is half the maximum value
2) Search for the samples around this value (2 on each side of the main lobe)
3) Computation of the indices associated with these values by linear interpolation
4) Conversion of indices into frequency
5) Computation of the difference between the 2 frequencies



The difference of travel between transmission and reference lines is computed by searching for the index of the sample that divides the energy of the spectrum by 2. Then, this index is converted into frequency and distance.

The parameters given by the processing of the PTR that have to be verified are:

- the width of the main lobe
- the difference of travel between the transmission and the reference lines

One quality flag for the total power of the PTR is output (Flag_Tot_Power).

ALGORITHM SPECIFICATION

Input data

- Number of samples of the PTR : Num_Val_PTR (/)
- Index associated with the zero frequency of the PTR : F0_PTR (/)
- Interval (in frequency) between two samples of the PTR : T_PTR (Hz)
- Samples of the PTR corrected for the effects of the low pass filter : Val_Cor_PTR [0:Num_Val_PTR-1] (1)
- Total power of the PTR : Tot_Power (1)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/)
- Order of the polynomial to fit the main lobe : Ord_Pol (/)
- Number of points used in the polynomial regression (must be an even number) : Num_Pts (/)
- Bandwidth of the signal : Bandwidth (Hz)
- Threshold percentage on the width of the main lobe : Thres_Width_Main_Lobe (/)
- Threshold percentage on the difference of travel : Thres_Diff_Trav (/)
- Reference value of the width of the main lobe : Ref_Width_Main_Lobe (Hz)
- Reference value of the difference of travel : Ref_Diff_Trav (m)
- Lower bound value of the frequency of the median : Low_Freq_Med_PTR (Hz)
- Upper bound value of the frequency of the median : Upp_Freq_Med_PTR (Hz)
- Pulse duration : Pulse_Duration (s)
- Light velocity : Light_Vel (m/s)

Output data

- Maximum value of the point target response : Max_Val_PTR (1)
- Frequency associated with the maximum of the PTR : Freq_Max_Val_PTR (Hz)
- Distance associated with the maximum of the PTR : Dist_Max_PTR (m)
- Difference of travel between the transmission and the reference lines : Diff_Trav (m)
- Associated flag : Flag_Diff_Trav (/)
- Width of the main lobe of the point target response at -3 dB : Width_Main_Lobe (Hz)
- Associated flag : Flag_Width_Main_Lobe (/)
- Frequency of the median point of the PTR in energy : Freq_Med_PTR (Hz)
- Associated flag : Flag_Freq_Med_PTR (/)
- Execution status

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(1) : FFT power unit

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to "valid" then the following processing must be implemented. If the validity flag is set to "invalid" then the output parameters are set to a default value.

- Determination of the precise position of the maximum value of the main lobe

The requested position (Freq_Max_Val_PTR) must be determined precisely in frequency. The following procedure is aimed at delivering a precise frequency of the maximum value of the main lobe (i.e. with a frequency resolution larger than the sampling frequency of the PTR).

1) The first step consists of finding the sample of the corrected PTR for which the amplitude of the main lobe is the greatest. Freq1_PTR and Val1_PTR are obtained.

   The frequencies associated with the samples of the PTR are obtained by:

   $$Freq_j = (j - F0\_PTR) * T\_PTR \quad \text{for j from 0 to Num\_Val\_PTR-1} \tag{1}$$

2) Selection of Num_Pts samples around the maximum value (Num_Pts/2 samples on the left, Num_Pts/2 samples on the right, Num_Pts<=6). The abscissa of these samples are x_i=i for i=1 to Num_Pts+1. Their ordinates are y_i for i=1 to Num_Pts+1(Num_Pts must be an even number and (Num_Pts +1) are used to performed the polynomial interpolation).

3) Computation of the coefficients of the polynomial that fits these Num_Pts+1 samples (order of the polynomial : Ord_Pol<=6 and Ord_Pol<=Num_Pts)

The method used to compute these coefficients is based on a least square method. The routine that implements this procedure is a routine of the NAG library E02ADF which computes weighted least-squares polynomial approximation to an arbitrary set of data points on a Chebyshev basis (RD13).

This routine determines a polynomial approximation of degree Ord_Pol represented as

$$T(\bar{x}) = \frac{1}{2} a_{i+1,1} T_0(\bar{x}) + a_{i+1,2} T_1(\bar{x}) + a_{i+1,3} T_2(\bar{x}) + K + a_{i+1,i+1} T_i(\bar{x})$$

where $T_j(x)$ is the Chebyshev polynomial of the first kind of degree j with argument (x).

The argument x must be first normalized from –1 to 1 according to the following linear transformation:

$$\bar{x} = \frac{(2x - x_{min} - x_{max})}{(x_{max} - x_{min})} \tag{2}$$

where x_{min} is equal to 1 and x_{max} is equal to Num_Pts+1.

This algorithm E02ADF is called to compute the polynomial approximation with the following arguments:

M = Number of data points = Num_Pts+1	[input]
KPLUS1 = k+1 where k is the max degree required = Ord_Pol+1 (<=7)	[input]
NROWS = Dimension of the Array A (must be >= KPLUS1) = 7	[input]
X = normalized values of x	[input]
Y = values of the PTR corresponding to the Num_Pts selected points	[input]
W = weight = array of Num_Pts+1 points equal to 1.	[input]
WORK1 = workspace of dimension : 3*(NumPts+1)	[/]

WORK2 = workspace of dimension : 2*(Ord_Pol+1) [/]

A = coefficients of Tj(x) of dimension (7,Ord_Pol+1) [Output]

S = root mean square residual of dimension Ord_Pol+1 [Output]

IFAIL = Indicator of the validity of the routine [Input/output]

IFAIL must be initialized to -1.

The coefficients of the polynomial approximation are obtained according to the following formula:

$$P(x) = b_0\bar{x}^n + b_1\bar{x}^{n-1} + b_2\bar{x}^{n-2} + K + b_{n-1}\bar{x} + b_n \quad \text{with}$$

when n<=6,

$$b_0 = 32a_{i+1,7} \tag{3}$$
$$b_1 = 16a_{i+1,6} \tag{4}$$
$$b_2 = 8a_{i+1,5} - 48a_{i+1,7} \tag{5}$$
$$b_3 = 4a_{i+1,4} - 20a_{i+1,6} \tag{6}$$
$$b_4 = 2a_{i+1,3} - 8a_{i+1,5} + 18a_{i+1,7} \tag{7}$$
$$b_5 = a_{i+1,2} - 3a_{i+1,4} + 5a_{i+1,6} \tag{8}$$
$$b_6 = \frac{1}{2}a_{i+1,1} - a_{i+1,3} + a_{i+1,5} - a_{i+1,7} \tag{9}$$

The coefficients b_i must have been initialized to “0” before equations (3) to (9).

4) Computation of the derivative function of this polynomial.

The coefficients c_i of P’(x) must be computed (from i=0 to Ord_Pol-1).

$$P'(x) = \sum_{i=0}^{n-1}(n-i)b_i\bar{x}^{(n-i-1)}$$

5) Search of the positions of the roots of this derivative function

The algorithm C02AGF (RD13) is called to compute all the roots of a real polynomial equation (using a modified Laguerre’s method) with the following arguments:

A = coefficients of P’(x) = c [input]

N = degree of the P’(x) polynomial = Ord_Pol-1 [input]

SCALE = indicates whether or not the polynomial is to be scaled = .TRUE. [input]

Z = Real and Imaginary parts of the roots in Z(1,i) and Z(2,i) for i = 1 to Ord_Pol-1 [output]

W = workspace of dimensions (2*(Ord_Pol)) [/]

IFAIL = Indicator of the validity of the routine [Input/output]

IFAIL must be initialized to -1.

The roots that will be retained must be real. If the algorithm doesn’t find any real root, the outputs are set to a default value. If several roots are obtained, the root for which the evaluation of the polynomial is greatest will be retained. The position of the maximum of the main lobe (Freq_Max_Val_PTR) and the value of this maximum (Max_Val_PTR) are then obtained. Freq_Max_Val_PTR is computed from the normalized value of the root obtained according to the following formula:

$$x_{root} = \frac{\bar{x}_{root}(x_{max} - x_{min}) + x_{min} + x_{max}}{2} \quad (10)$$

$$Freq\_Max\_Val\_PTR = \left(x_{root} - \frac{Num\_Pts}{2} - 1 \right) * T\_PTR + Freq1\_PTR \quad (11)$$

The distance associated to this frequency is computed according to the next formula :

$$Dist\_Max\_PTR = Freq\_Max\_Val\_PTR * \frac{Pulse\_Duration * Light\_Vel}{2.0 * Bandwidth}$$

- Determination of the width of the main lobe at –3dB

The half power width (Width_Main_Lobe) is determined according to the following procedure:

6) Computation of the half power (Half_Power) which is half the maximum value of the PTR (Max_Val_PTR).

$$Half\_Power = \frac{Max\_Val\_PTR}{2} \quad (12)$$

7) For the left side of the main lobe (for frequencies smaller than Freq_Max_Val_PTR), search of the sample which value is just smaller than Half_Power and search of the sample which value is just greater than Half_Power. Then a linear interpolation between these 2 points is implemented in order to find the frequency of the point of the linear interpolation that has a value equal to Half_Power. Freq1 and Freq2 are the frequencies of the 2 samples taken into account to perform the interpolation. The amplitudes of the samples at Freq1 and Freq2 are Y1 and Y2.

The equation of the linear interpolation is:

$$Y = A * Freq + B \quad (13)$$

$$\text{with } A = \frac{(Y1 - Y2)}{(Freq1 - Freq2)} \quad (14)$$

$$B = Y1 - A * Freq1 \quad (15)$$

The frequency of the Half power point is:

$$Freq\_Half\_Power\_Left = \frac{Half\_Power - B}{A} \quad (16)$$

The same procedure is performed for the right side of the main lobe. The frequency Freq_Half_Power_Right is obtained.

8) The width of the main lobe of the PTR is obtained by computation of the difference between the 2 frequencies :

$$\mathrm{Width\_Main\_Lobe} = \mathrm{Freq\_Half\_Power\_Right} - \mathrm{Freq\_Half\_Power\_Left} \tag{17}$$

- Determination of the difference of travel between the transmission and the reference lines

The difference of travel is computed by searching for the index of the sample that divides the energy of the spectrum by 2.

9) The first step is to search the indices min and max (Ind_Min and Ind_Max) of the PTR array, symetric compared with the max value of the main lobe of the PTR. Then, the power will be integrated between these two limits.

10) The second step is to compute the power integrated between the index Ind_Min and the current index (cumulative function of the PTR array) according to the next formula:

$$\mathrm{Int\_Power}_j = \sum_{k=\mathrm{Ind\_Min}}^{j} \mathrm{Val\_Cor\_PTR}_k \tag{18}$$

11) Then the index j of the point for which Int_Power is just smaller than Tot_Power/2 is Left_Ind. The following point is Right_Ind (Left_Ind+1). The following relation is then verified:

$$\mathrm{Int\_Power}_{\mathrm{Left\_Ind}} \le \frac{\mathrm{Tot\_Power}}{2} \le \mathrm{Int\_Power}_{\mathrm{Right\_Ind}} \tag{19}$$

12) A linear interpolation is then implemented according to the next formula to determine the pseudo-index of the sample for which the energy is equal on the right and on the left of this point.

$$\mathrm{Ind\_mil} = \mathrm{Left\_Ind} + \frac{\mathrm{Right\_Ind} - \mathrm{Left\_Ind}}{\mathrm{Int\_Power}_{\mathrm{Right\_Ind}} - \mathrm{Int\_Power}_{\mathrm{Left\_Ind}}} * \left(\frac{\mathrm{Tot\_Power}}{2} - \mathrm{Int\_Power}_{\mathrm{Left\_Ind}} \right) \tag{20}$$

13) The Ind_Mil index is then converted into frequency (Freq_Med_PTR) (according to the formula (1)) and distance according to the next formula:

$$\mathrm{Diff\_Trav} = \mathrm{Freq\_Med\_PTR} * \frac{\mathrm{Pulse\_Duration} * \mathrm{Light\_Vel}}{2.0 * \mathrm{Bandwidth}} \tag{21}$$

14) The parameters given by the processing of the PTR that have to be verified are:

- The width of the main lobe
- The difference of travel between the transmission and the reference lines
- The frequency of the energetic median of the PTR

These parameters have to be compared to the parameters computed from the PTR that was used to compute the tables of correction (see Appendix 1).

For the width and the difference of travel, this is performed using the mechanism (AD11) "GEN_MEC_QUA_04 - Check of a parameter versus a reference value". The input of the mechanism are:

- Parameter to be checked : X
- Reference value of the parameter : Ref_X (same unit as X)
- Threshold percentage : Thres_X (/)

The output is the validity flag of the parameter Flag_X (2 states)

For the frequency of the median of the PTR, this is performed using the mechanism (AD11) "GEN_MEC_QUA_01 - Quality check from thresholds". The input of the mechanism are:

- Parameter to be checked : X
- Lower bound : Low_X (same unit as X)
- Upper bound : Upp_X (same unit as X)

The output is the validity flag of the parameter Flag_X (2 states)

Finally, in output, the following flags are issued:

- One flag for the width of the main lobe : Flag_Width_Main_Lobe
- One flag for the difference of travel between the transmission and the reference lines : Flag_Diff_Trav
- One flag for the energetic median of the PTR: Flag_Freq_Med_PTR.

ACCURACY

N/A

COMMENTS

The number of points used in the polynomial regression will depend on the sampling frequency of the PTR. It will be greater if the sampling frequency is high (T_PTR small).

REFERENCES

None

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ALT_CAL_PTR_04 - To compute the characteristics of the secondary lobes of the PTR

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
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HERITAGE

POSEIDON-1

FUNCTION

To check the values of the samples in the PTR and to compute the positions and the values of the maxima of the secondary lobes.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of samples of the PTR
  - Index associated with the zero frequency of the PTR
  - Interval (in frequency) between two samples of the PTR
- Computed data:
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Samples (power) of the point target response corrected for the effects of the low pass filters
    - Validity flag of the corrected PTR
  - From "ALT_CAL_PTR_03 - To compute the characteristics of the main lobe of the PTR":
    - Maximum value of the PTR
    - Frequency associated with the maximum of the PTR
- Static auxiliary data:
  - Processing parameters:
    - Order of the polynomial to fit to the lobes
    - Number of points used for the polynomial regression
    - Constant of proportionality between the maximum value of the PTR and the limit value allowed for the secondary lobes
    - Number of secondary lobes

Output data

- Powers associated with the maxima of the secondary lobes of the PTR
- Positions (in frequency) of the maxima of the secondary lobes of the PTR
- Likelihood flag for the secondary lobes

Mathematical statement

The detection of the secondary lobes is performed using the following procedure:

- Main lobe:

  For the left part of the main lobe it is verified that the power increases (for decreasing frequencies from the freq. of the max of the PTR), and for the right part of the main lobe that the power decreases (for increasing frequencies from the freq. of the max of the PTR). The indices corresponding to the beginning (I_BEG_ML) and the end (I_END_ML) of the main lobe are computed. If these indices can't be found, an error message is produced and the processing is stopped.

- Secondary lobes:

  Outside the main lobe, the procedure that has been described for the main lobe is used to determine the indices of beginning and end of the secondary lobes (Num_LSC secondary lobes have to be considered ie Num_LSC/2 lobes for each side of the main lobe). It is also determined the frequency of the maximum of each secondary lobe and the values of these maximum. The procedure used to implement this function is the same as the procedure used to determine the frequency of the maximum of the main lobe (see ALT_CAL_PTR_03 - To compute the characteristics of the main lobe of the PTR).

  It is verified that the values of the samples do not exceed a threshold value.

  A likelihood flag associated with the secondary lobes is determined.

ALGORITHM SPECIFICATION

Input data

- Number of samples of the PTR : Num_Val_PTR (/)
- Index associated with the zero frequency of the PTR : F0_PTR (/)
- Interval (in frequency) between two samples of the PTR : T_PTR (Hz)
- Samples of the PTR corrected for the effects of the low pass filter : Val_Cor_PTR [0:Num_Val_PTR-1] (1)
- Maximum value of the PTR : Max_Val_PTR (1)
- Frequency associated with the maximum of the point target response : Freq_Max_Val_PTR (Hz)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/) (2)
- Order of the polynomial that fits to the main lobe : Ord_Pol (/)

---

(1) : FFT power unit

(2) : 2 states "valid and "invalid"

- Number of points used for the polynomial regression : Num_Pts (/)
- Number of secondary lobes of the PTR (must be an even number) : Num_LSC (/)
- Constant of proportionality between the maximum value of the PTR and the limit value allowed for the secondary lobes : Percent_Val (/)

Output data

- Powers associated with the maxima of the secondary lobes of the PTR : Max_Power_LSC [0:Num_LSC-1] (1)
- Positions of the maxima of the secondary lobes of the PTR : Freq_Max_LSC [0:Num_LSC-1] (Hz)
- Flags for the secondary lobes : Flag_LSC [0:Num_LSC-1] (/) (2)
- Likelihood flag for all the secondary lobes : Flag_PTR (/) (2)
- Execution status

Processing

If the validity flag (Flag_Val_Cor_PTR) is set to "invalid" then the output parameters are set to a default value.

else the following procedure is performed:

- Main lobe:

  For the left part of the main lobe it is verified that the power decreases (for decreasing frequencies from Freq_Max_Val_PTR)

  $$Val\_Cor\_PTR_{j-1} < Val\_Cor\_PTR_{j} \quad \text{for j on the left side of the main lobe (I\_Beg\_ML<j<Ind\_Max)} \qquad (1)$$

  Ind_Max is the index corresponding to the first point after the maximum of the PTR.

  and for the right part of the main lobe that the power decreases (for increasing frequencies from Freq_Max_Val_PTR).

  $$Val\_Cor\_PTR_{k} > Val\_Cor\_PTR_{k+1} \quad \text{for k on the right side of the main lobe (Ind\_Max<k<I\_End\_ML)} \qquad (2)$$

  The indices corresponding to the beginning (I_Beg_ML) and the end (I_End_ML) of the main lobe are computed. The aim is to determine the "limit" indices (low and high) of the main lobe. The "j" point for which (1) is not verified is I_Beg_ML and the "k" point for which (2) is not verified is I_End_ML.

  If (1) or (2) are not satisfied, the outputs are set to a default value and Flag_LSC and Flag_PTR are set to "invalid".

- Secondary lobes:

  Outside the main lobe, the procedure that has been described for the main lobe is used to determine the indices of the beginning and end of each of the secondary lobes (Num_LSC secondary lobes have to be considered). It is also determined the frequency of the maximum of each secondary lobe and the values of these maximum. The procedure used to implement this function is the same as the procedure used to determine the frequency of the maximum of the main lobe (see "ALT_CAL_PTR_03 - To compute the characteristics of the main lobe of the PTR").

---

(1) : FFT power unit

Outside the main lobe, it is verified that the values of the samples don't exceed a threshold value.

$$Val\_Cor\_PTR_j \le \frac{Max\_Val\_PTR}{Percent\_Val} \quad \text{for } j \in [0, I\_Beg\_ML - 1] \quad \text{or} \quad j \in [I\_End\_ML + 1, Num\_Val\_PTR - 1] \quad (3)$$

and Max_Val_PTR is the maximum value of the PTR

Percent_Val is a constant (for example Percent_Val=20 is equivalent to a 13dB attenuation between the max value of the PTR and the values of the other lobes).

For each secondary lobe "i" of the PTR, the flag associated with this secondary lobe is set to "valid" if the secondary lobe has been identified (I_Beg_LSC(i), I_End_LSC(i), Freq_Max_LSC(i), Max_Power_LSC(i)) and if the relation (3) is verified for all the samples of the secondary lobe.

If all the secondary lobes are "valid", then the likelihood flag Flag_PTR is set to "valid". If one of them is "invalid", then the likelihood flag Flag_PTR is set to "invalid".

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

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ALT_CAL_GEN_01 - To generate waveforms

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To generate waveforms without speckle according to the Hayne's model.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Interval (in frequency) between two samples of the PTR
- Computed data:
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Validity flag of the corrected PTR
- Static auxiliary data:
  - Processing parameters
    - Number of samples of the waveform
    - Reference altitude of the satellite
    - Scale factor
    - Antenna beamwidth at 3dB (depending of the bandwidth of the signal)
    - Value of the automatic gain control (depending of the bandwidth of the signal)
    - Waveform amplitude (depending of the bandwidth of the signal)
    - Thermal noise level (depending of the bandwidth of the signal)
    - Significant waveheight
    - Offset of the tracking point
  - POSEIDON-2 instrumental characterization data
    - Pulse duration
    - Bandwidth of the signal

- Universal constants
  - Light velocity
  - Earth radius

Output data

- Samples of the waveform
- Index associated with the reference sample for tracking ("half of the leading edge")

Mathematical statement

The expression of the waveform according to Hayne's model is given by:

$$S_1(\nu) = \frac{1}{2}.\left\{1 + \operatorname{erf}\left[\frac{(t-\tau) - \alpha.\sigma_c^2}{\sqrt{2}.\sigma_c}\right]\right\}.\exp\left[-\alpha.\left((t-\tau) - \frac{\alpha.\sigma_c^2}{2}\right)\right] \quad (1)$$

with: $\alpha = \dfrac{4.c}{\gamma.H_{sat}.\left(1 + \dfrac{H_{sat}}{R_e}\right)}$ α is given in Hz

$\sigma_c = \dfrac{SWH}{2.c}$ given in s

t : Datations of the samples of the signal (s)

τ : Offset of the tracking point (s)

c : Light velocity (m/s)

H_{sat} : Satellite altitude (m)

R_e : Earth radius (m)

SWH : Significant waveheight (m)

$\gamma = \dfrac{2}{Log_e(2)}.\sin^2(\dfrac{\theta}{2})$, where θ is the antenna beamwidth at 3 dB

The signal is scaled according to:

$$S(\nu) = V_{nom}.10^{\frac{-AGC}{10}}.[P_u.S_1(\nu) + P_n] \quad (2)$$

V_{nom} : scale factor

AGC : value of the automatic gain control (dB)

P_u : Waveform amplitude (FFT power unit)

P_n : Thermal noise level (FFT power unit)

The signal is computed with a sampling frequency equal to the sampling frequency of the PTR.

ALGORITHM SPECIFICATION

Input data

- Number of samples of the waveform : Num_Val_Wave (/)
- Interval (in frequency) between two samples of the PTR : T_PTR (Hz)
- Bandwidth of the signal : Bandwidth (Hz)
- Pulse duration : Pulse_Duration (s)
- Light velocity : Light_Vel (m/s)
- Reference altitude of the satellite : H_Alt (m)
- Earth radius : Earth_Rad (m)
- Scale factor : Vnom (/)
- Antenna beamwidth at 3dB (depending of the bandwidth of the signal) : Theta0 (degree)
- Value of the AGC (depending on the bandwidth of the signal) : AGC (dB)
- Waveform amplitude (depending on the bandwidth of the signal) : Ampl (FFT power unit)
- Thermal noise level (depending of the bandwidth of the signal) : Noise (FFT power unit)
- Significant waveheight of the waveform : SWH (m)
- Offset of the tracking point (1) : Offset (/)
- Validity Flag of the Corrected PTR : Flag_Val_Cor_PTR (/) (2)

Output data

- Samples of the waveform : Val_Wave [0:Num_Val_Wave-1] (3)
- Index associated with the reference sample for tracking : F0_Wave (/)
- Execution status

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to “invalid” then the output parameters are set to a default value.

---

(1) The waveform will be left-shifted for a positive value of the offset

(2) 2 states : “valid” and “invalid”

(3) FFT power unit

Else the following processing must be implemented.

In order to compute the Hayne's model, the following parameters must be computed:

Gamma and Alpha are computed using mechanism "GEN_MEC_MOD_04 - Computation of "Gamma" and "Alpha" altimeter parameters" (AD11).

The inputs of the mechanism are:

* Antenna beamwidth : Theta0 (degree)
* Satellite altitude : H_Alt (m)
* Earth radius : Earth_Rad (m)
* Light velocity : Light_Vel (m/s)

The outputs of the mechanism are:

* "Gamma" parameter : Gamma (/)
* "Alpha" parameter : Alpha (s^{-1})
* Execution status

$$\text{SigmaC} = \frac{\text{SWH}}{2 * \text{Light\_Vel}} \tag{1}$$

The datation vector t is given by the next formula where j is the index of the sample in the waveform (from 0 to Num_Val_Wave-1) :

$$t = \left[j - \frac{\text{Num\_Val\_Wave}}{2} + \text{Offset} \right] * \frac{\text{T\_PTR}}{\text{Bandwidth}} * \text{Pulse\_Duration} \tag{2}$$

The signal is generated on Num_Val_Wave points with a sampling frequency equal to the sampling frequency of the PTR. The index associated with the reference sample for tracking is equal to :

$$\text{F0\_Wave} = \frac{\text{Num\_Val\_Wave}}{2} - \text{Offset} \tag{3}$$

Then, the waveform is computed by:

$$S(j) = \frac{1}{2} * \left\{ 1 + \text{erf}\left[\frac{t - \text{Alpha} * \text{SigmaC}^2}{\sqrt{2} * \text{SigmaC}} \right] \right\} * \exp\left[-\text{Alpha} * \left(t - \frac{\text{Alpha} * \text{SigmaC}^2}{2} \right) \right] \tag{4}$$

Then, the signal must account for the scaling factor, the AGC gain, the amplitude and the thermal noise level, according to:

$$Val\_Wave(j) = Vnom * 10^{\frac{-AGC}{10}} * [Ampl * S(j) + Noise] \quad (5)$$

ACCURACY

N/A

COMMENTS

The waveform is generated with a sampling frequency that is the nominal sampling frequency of the PTR in the “Altimeter Level 1B processing”. For the “Expertise CMA processing”, the sampling frequency of the PTR is used to generate the waveform (so in this case, T_PTR can be smaller than T_Nom_PTR).

REFERENCES

- **Ref. 1:** Hayne G.S. 1980: "Radar Altimeter Mean Return Waveforms from Near-Normal-Incidence Ocean Surface Scattering". IEEE Trans. on antennas and propagation, Vol. AP-28, n°5, pp. 687-692.

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ALT_CAL_GEN_02 - To apply calibrations

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To perform the convolution of the waveform with the PTR of the altimeter and to apply the filter on the signal.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of samples of the PTR
  - Index associated with the zero frequency of the PTR
- Computed data:
  - From "ALT_CAL_GEN_01 - To generate waveforms":
    - Samples of the waveform
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Samples of the PTR corrected for the effects of the filter
    - Validity flag of the corrected PTR
  - From “ALT_CAL_LPF_06 - To sample the filter at a new sampling frequency”:
    - Samples of the filter
    - Number of samples of the filter
- Static auxiliary data:
  - Processing parameters
    - Number of samples of the waveform
  - POSEIDON-2 instrumental characterization data
    - Values of the filter taken as reference for the mission

Output data

- Samples of the signal taking into account the PTR and the filter

Mathematical statement

The main steps are:

- Convolution of the signal with the PTR using a FFT method (both signals have the same sampling frequency).
- Normalization of the signal with the power of the PTR (RNORM) according to:

$$\text{Signal}_k = \frac{\text{Signal}_k}{\text{RNORM}} \quad (1)$$

with: k from 1 to the number of samples of the waveform:

$$\text{RNORM} = \sum_{j=1}^{\text{Number\_of\_samples\_PTR}} \text{PTR}_j$$

Both signals have the same sampling frequency. They have the same number of samples.

- Application of the filter (for all samples of the waveform), according to:

$$\text{Signal}_k = \text{Signal}_k * \text{Filter}_k \quad (2)$$

ALGORITHM SPECIFICATION

Input data

- Number of samples of the waveform : Num_Val_Wave (/)
- Number of samples of the PTR : Num_Val_PTR (/)
- Number of samples of the filter : Num_Val_Filter (/)
- Samples of the PTR (corrected for the LPF spectrum) : Val_Cor_PTR [0:Num_Val_PTR-1] (1)
- Index associated with the zero frequency of the PTR : F0_PTR (/)
- Samples of the waveform : Val_Wave [0:Num_Val_Wave-1] (1)
- Samples of the filter : Val_Filter [0:Num_Val_Filter-1] (/)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/) (2)

Output data

- Samples of the signal taking into account the PTR and filter : Val_Signal [0:Num_Val_Wave-1] (1)
- Execution status

(1) : FFT power unit

(2) 2 states : "valid" and "invalid"

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to “valid” then the following processing must be implemented. If the validity flag is set to “invalid” then the output parameters are set to a default value.

This procedure is implemented if Num_Val_Wave = Num_Val_PTR=Num_Val_Filter. If not, output is set to a default value.

- The convolution of the signal by the Point Target Response is obtained by the Fast Fourier Transform method.

If $Z = X \otimes Y$ then Z can be obtained by: $Z = FFT^{-1}[FFT(X) * FFT(Y)]$

The FFT algorithm used is issued from the NAG mathematical library (RD13).

The first step is to compute the FFT of the signal Val_Wave with Num_Val_Wave samples and the FFT of the Point Target Response with Num_Val_PTR samples.

$$S1 = FFT\{Val\_Wave\} \quad (1)$$

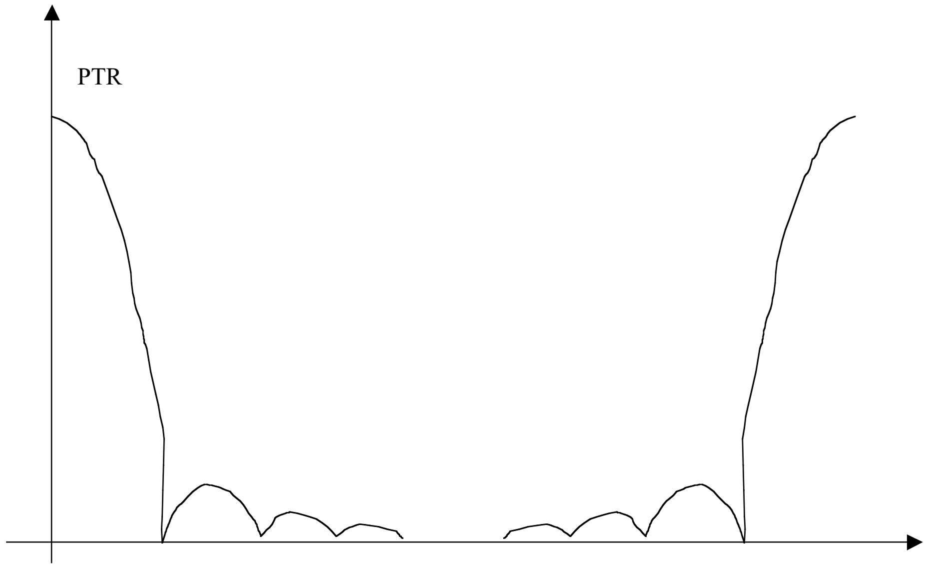
$$S2 = FFT\{Val\_PTR\} \quad (2)$$

The algorithm used to compute the direct FFT is C06ECF which calculates the discrete Fourier transform of a sequence of N complex data values.

This algorithm C06ECF is called to compute the FFT of the waveform with the following arguments:

X = array (real parts) with bounds from 0 to N-1 = Val_Wave	[input/output]
Y = array (imaginary parts) with bounds from 0 to N-1 = Array of “0”	[input/output]
N = number of data values = Num_Val_Wave	[input]
IFAIL = Indicator of the validity of the routine (IFAIL must be initialized to -1)	[Input/output]

Before computing the DFT of the PTR, the array of the PTR must be reorganized with the 0 frequency of the PTR on the left side of the array and the negative frequency values on the right side.



Initial array	F0_PTR	...				N-1	0	1	2	3	4	...	F0_PTR-1
Reorganized array	0	1	2	3	4	...	F0_PTR	F0_PTR+1	...		N-2	N-1	

The 0-frequency of the PTR must be set in the first position in the reorganized array. The last point of the reorganized array must be the first negative frequency of the initial array.

This algorithm C06ECF is called to compute the FFT of the PTR with the following arguments:

X = array (real parts) with bounds from 0 to N-1 = Val_PTR	[input/output]
Y = array (imaginary parts) with bounds from 0 to N-1 = Array of "0"	[input/output]
N = number of data values = Num_Val_PTR	[input]
IFAIL = Indicator of the validity of the routine (IFAIL must be initialized to -1)	[Input/output]

The product S1 * S2 is obtained by direct complex multiplication of the samples from 0 to Num_Val_Wave-1 (equivalent to Num_Val_PTR-1). The result can be stored in a temporary variable: S [0:Num_Val_PTR-1]

If S1=a1+jb1 and S2=a2+jb2 then the complex multiplication gives S1*S2=(a1*a2-b1*b2)+j(a1*b2+a2*b1)

Then the signal is obtained by inverse FFT of the product S1*S2:

$$S = FFT^{-1}\{S1 * S2\} \qquad (3)$$

To compute the inverse discrete Fourier transforms, C06ECF must be used in conjunction with C06GCF which forms the complex conjugate of the output of C06ECF. C06ECF must be preceded and followed by calls of C06GCF.

The algorithm used to compute the complex conjugate is C06GCF with the following arguments:

X = array (imaginary parts) with bounds from 0 to N-1 = Im(S)	[input/output]
N = number of data values = Num_Val_Wave	[input]

IFAIL = Indicator of the validity of the routine (IFAIL must be initialized to -1) [Input/output]

This algorithm C06ECF is called to compute the FFT of the waveform with the following arguments:

X = array (real parts) with bounds from 0 to N-1 = Re(S) [input/output]

Y = array (imaginary parts) with bounds from 0 to N-1 = Im(S) [input/output]

N = number of data values = Num_Val_Wave [input]

IFAIL = Indicator of the validity of the routine (IFAIL must be initialized to -1) [Input/output]

And the algorithm used to compute the complex conjugate is C06GCF with the following arguments:

X = array (imaginary parts) with bounds from 0 to N-1 = Im(S) issued from CO6ECF[input/output]

N = number of data values = Num_Val_Wave [input]

IFAIL = Indicator of the validity of the routine (IFAIL must be initialized to -1) [Input/output]

The signal S obtained is quasi-real (imaginary part of the S signal is very weak). So the last call to C06GCF can be omitted but left as a commentary.

- The signal is normalized according to the next formula:

$$Val\_Signal = \frac{Re(S) * \sqrt{Num\_Val\_PTR}}{Norm} \tag{4}$$

with $$Norm = \sum_{m=0}^{Num\_Val\_PTR-1} Val\_PTR_m \tag{5}$$

- Application of the filter for k from 0 to Num_Val_Wave-1 (=Num_Val_PTR-1=Num_Val_Filter-1)

$$Val\_Signal_k = Val\_Signal_k * Val\_Filter_k \tag{6}$$

Note that the filter has been selected by a management algorithm previously (filter measured or reference filter).

ACCURACY

N/A

COMMENTS

The sampling frequencies of the signal and the PTR must be equal (nominal calibration scenario).

REFERENCES

None

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ALT_CAL_GEN_03 - To sample the signal and apply noise to it

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To sample the signal at a reference frequency f_{ref} and apply noise to it.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Number of pulses in an altimeter cycle
- Computed data:
  - From "ALT_CAL_GEN_02 - To apply calibrations":
    - Samples of the waveforms taking into account the PTR and the filter.
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Validity flag of the corrected PTR.
- Static Auxiliary data:
  - Processing parameters
    - Number of samples of the input waveform that takes into account the PTR
    - Number of samples of the signal after f_{ref} sampling
    - Interval (in frequency) between two samples of the input waveform
    - Interval (in frequency) between two samples of the waveform after f_{ref} sampling

Output data

- Samples of the signal with noise added to it at the f_{ref} sampling frequency.

Mathematical statement

In order to be able to compare the influences of the calibration measurements on the altimetric parameters estimation, the signal must be sampled at a reference sampling frequency f_{ref}. f_{ref} must be a multiple of the sampling frequency of the point target response.

Noise is then added to the signal V as follows:

$$IV_j = V_j\left(1+\frac{Speckle_j}{\sqrt{Num\_Pulse}}\right) \quad (1)$$

where j is the index of the sample in output, Num_Pulse is the number of pulses integrated during a cycle of the altimeter and Speckle is an array of random numbers (gaussian distribution with 0-mean and unit standard deviation).

ALGORITHM SPECIFICATION

Input data

- Number of samples of the input waveform taking into account the PTR : Num_Val_Wave (/)
- Number of pulses integrated in an altimeter cycle : Num_Pulse (/)
- Samples of the input waveform taking into account the PTR : Val_Signal [0:Num_Val_Wave-1][(1)]
- Number of samples of the signal after f_{ref} sampling : Num_Sampl_IV (/)
- Interval (in frequency) between two samples of the input waveform : T_In_Wave (Hz)
- Interval (in frequency) between two samples of the output waveform : T_Out_Wave (Hz)
- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/)[(2)]

Output data

- Samples of the noised signal at the f_{ref} sampling frequency : IV [0:Num_Sampl_IV-1] [(1)]
- Execution status

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to “invalid” then the output parameters are set to a default value.

Else the following processing must be implemented.

---

(1) FFT power unit

(2) 2 states : “valid” and “invalid”

First of all it must be verified that T_Out_Wave is a multiple k of the sampling frequency of the PTR and that k is also the ratio between Num_Val_Wave and Num_Sampl_IV. If this condition is not satisfied, then output parameters are set to default values and the procedure returns an error message.

This algorithm can be split in three steps:

- Generation of the noise

The Num_Sampl_IV samples of noise $Speckle_k$ must be generated. They follow a 0-mean and unit standard deviation gaussian distribution. The mathematical function used to perform this operation is taken in the NAG mathematical library (RD13).

In order to have always the same sequence of random numbers, the internal seed used by the basic generator has to be initiated by the NAG function G05CBF with the following argument:

I = set to 0	[input]

Then the routine G05FDF is used to generates of vector of pseudo-random numbers from Normal distribution with mean a and standard deviation b. The routines uses the Box-Muller method. The following arguments are used :

A = mean a of the distribution = 0	[input]
B = standard deviation b of the distribution = 1	[input]
N =number n of pseudo-random numbers to be generated = Num_Sampl_IV	[input]
X = the n pseudo-random numbers from the specified normal distribution = Speckle	[output]

- Sampling of the waveform

The signal must be sampled at a reference sampling frequency f_{ref} (T_Out_Wave). T_Out_Wave must be a multiple of the sampling frequency of the point target response. If the sampled signal is noted V_j then it is obtained by (j goes from 0 to Num_Sampl_IV-1) :

$$Rap\_Freq = NINT\left[\frac{T\_Out\_Wave}{T\_In\_Wave}\right] \quad (1)$$

$$V_j = Val\_Signal_{j*Rap\_Freq} \quad (2)$$

- Addition of speckle on the signal

Then the noise is added to the signal according to the next formula:

$$IV_j = V_j\left(1+\frac{Speckle_j}{\sqrt{Num\_pulse}}\right) \quad (3)$$

where j goes from 0 to Num_Sampl_IV-1 and Num_Pulse is the number of pulses integrated during a cycle of the altimeter

ACCURACY

N/A

COMMENTS

The initialization of the random numbers generation is always the same when entering the algorithm (reproducibility).

The sampling frequency of the waveform in output is the same as the sampling frequency of the waveform processed in the altimeter level 1B processing (128 samples with a sampling frequency of 10kHz).

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_CAL_GEN_04 - To estimate the altimetric parameters

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To estimate the values of the altimetric parameters from the waveform with the ocean-2 on-ground retracking algorithm (see "ALT_RET_OCE_02 - To perform the ocean-2 retracking" in RD4).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
- Computed data:
  - From "ALT_CAL_GEN_03 - To sample the signal and apply noise to it":
    - Samples of the noised waveform accounting for the PTR and the filter
  - From "ALT_CAL_PTR_01 - To correct the Point Target Response":
    - Validity flag of the corrected PTR
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data: see " ALT_RET_OCE_02 - To perform the ocean-2 retracking" in RD4
  - Processing parameters: see " ALT_RET_OCE_02 - To perform the ocean-2 retracking" in RD4 + offset of the tracking point
  - Universal constants: see " ALT_RET_OCE_02 - To perform the ocean-2 retracking" in RD4

Output data

The following parameters:

- Epoch: τ
- Composite Sigma: σ_c
- Amplitude: P_u

- Thermal noise level: P_n
- Slope of the logarithm of the trailing edge: s_T
- Mean quadratic error between the normalized waveform and its model
- Number of iterations
- Quality information, such as an execution flag (valid / invalid)

Mathematical statement

See " ALT_RET_OCE_02 – To perform the ocean-2 retracking" in RD4.

As mentioned in RD4, it will be possible to run a specific scenario to process C-band waveforms with a 100-MHz bandwidth (processing option). Regarding the CAL processing, this scenario is designed to account for a default value of the composite sigma, which could be the value corresponding to the significant waveheight used on input of "ALT_CAL_GEN_01 - To generate waveforms" (the corresponding PTR width is requested on input of the retracking algorithm). In this scenario, the epoch and the amplitude will be estimated, while the composite sigma will remain constant.

ALGORITHM SPECIFICATION

Input data

- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/) (“valid” or “invalid”)
- Waveform:
  - Number of samples : Num_Sampl_IV (/)
  - Samples amplitude : IV [0:Num_Sampl_IV-1] (FFT power unit)
- Offset of the tracking point : Offset (/)
- Characterization data:
  - Sampling interval of the analysis window : FFT_Step (s)
  - Antenna beamwidth : Ant_Beam (degree)
  - Ratio PTR width / FFT step : Ratio_PTR_FFT (/)
- Processing Parameters
  - Orbit altitude : H_Alt (m)
- Processing parameters for the ocean-2 retracking [(3)] : See " ALT_RET_OCE_02 – To perform the ocean-2 retracking" in RD4.
- Light velocity : Light_Vel (m/s)
- Earth radius : Earth_Rad (m)

[(3)] Contains in particular the retracking option (Retrack_Option, set to "Nominal" or "Reduced")

Output data

- Retracking estimates:
  - Epoch : Epoch (s)
  - Width of the leading edge (composite Sigma) [(4)] : SigmaC (s)
  - Amplitude : Ampl (FFT power unit)
  - Thermal noise level : Therm_Noise (FFT power unit)
  - Slope of the log. of the trailing edge for mispointing : Slope (s^{-1})
- Quality information:
  - Execution of the retracking algorithm : Flag_Retrack ("valid" or "invalid")
  - Mean quadratic error in the estimation window : MQE (/)
  - Number of iterations : Iter (/)
- Execution status

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) is set to “invalid” then the output parameters are set to a default value.

Else the following processing must be implemented.

The algorithm called to perform the retracking is " ALT_RET_OCE_02 – To perform the ocean-2 retracking" in RD4. The input are :

- Processing flag for the ocean-2 retracking : Flag_Val_Cor_PTR ("valid" or "invalid")
- Waveform:
  - Number of samples : Num_Sampl_IV
  - Abscissa of samples in the analysis window : array [0,1,2,…, Num_Sampl_IV-1]
  - Samples amplitude : IV [0:Num_Sample_IV-1]
- Waveform features:
  - Sampling interval of the analysis window [(1)] : FFT_Step
  - Abscissa of the reference sample for tracking [(1)] : Offset
  - Waveform quality flag : set to "valid"
  - Antenna beamwidth [(2)] : Ant_Beam
  - Ratio PTR width / FFT step : Ratio_PTR_FFT

[(4)] Converted initial value if Retrack_Option is set to "Reduced"

[(1)] Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

[(2)] Value to be selected according to the processed band

- Initialization parameters:
  - Execution of the retracking algorithm : set to "invalid"
  - Width of the leading edge : set to "default"
  - Sampling interval of the analysis window : set to "default"
- Square of the off-nadir angle : set to "0"
- Orbit altitude : H_Alt
- Processing parameters for the ocean-2 retracking[3]:
  - Retracking option : Retrack_Option
  - Slope option : Slope_Option
  - Skewness coefficient : Skew_Coeff
  - Default value of the epoch : Epoch_Def (s)
  - Default value of the significant waveheight : SWH_Def (m)
  - Default value of the amplitude : Ampl_Def (FFT power unit)
  - Abscissa of the first sample for noise estimation : Tn_First (/)
  - Abscissa of the last sample for noise estimation : Tn_Last (/)
  - Maximum number of iterations in the estimation process : Max_Iter (/)
  - Minimum SWH value in the estimation process : SWH_Min (m)
  - Maximum SWH value in the estimation process : SWH_Max (m)
  - Abscissa of the first sample for estimation : Ew_First (/)
  - Abscissa of the last sample for estimation : Ew_Last (/)
  - Threshold for the F04AMF NAG routine : Thresh_F04AMF (/)
  - Estimation loop gain for the epoch : Loop_Gain_Epoch (/)
  - Estimation loop gain for the composite sigma : Loop_Gain_SigmaC (/)
  - Estimation loop gain for the amplitude : Loop_Gain_Ampl (/)
  - Maximum value of the epoch increments : Max_Inc_Epoch (s)
  - Maximum value of the composite sigma increments : Max_Inc_SigmaC (s)
  - Maximum value of the amplitude increments : Max_Inc_Ampl (FFT power unit)
  - Minimum value of the amplitude : Min_Ampl (FFT power unit)
  - Minimum number of iterations in the estimation process [10] : Min_Iter (/)
  - Threshold for the MQE ratio testing : Th_Ratio (/)
  - Limit argument for the erf function (absolute value) : Arg_Limit (/)

---

[3] Values to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

[10] Min_Iter is greater or equal to 2

  - Beginning of the window for the slope of the trailing edge : Abs_S_First (/)
  - End of the window for the slope of the trailing edge : Abs_S_Last (/)
- Earth radius : Earth_Rad (m)
- Light velocity : Light_Vel (m/s)

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

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ALT_CAL_GEN_05 - To check the parameters issued from the estimation

DEFINITION, ACCURACY AND SPECIFICATION

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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To check the parameters that have been computed by the on-ground retracking algorithm.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data: None
- Computed data:
  - From "ALT_CAL_GEN_04 - To estimate the altimetric parameters":
    - Epoch
    - Composite Sigma
    - Amplitude
    - Slope of the logarithm of the trailing edge
    - Quality information, such as an execution flag (valid / invalid)
  - From “ALT_CAL_PTR_01 - To correct the Point Target Response”:
    - Validity flag of the corrected PTR
- Static auxiliary data:
  - Characterization data (parameters computed for the prelaunch general calibration estimations):
    - Epoch
    - Composite Sigma
    - Amplitude
    - Slope of the logarithm of the trailing edge
    - Thresholds on the estimation of the above-mentioned altimetric parameters

Output data

Quality flags for each estimated altimetric parameter:

- Epoch
- Composite Sigma
- Amplitude
- Slope of the logarithm of the trailing edge
- Quality flag for the overall estimation process

Mathematical statement

The aim of this algorithm is to determine if the estimated parameters are close to the parameters that were obtained when generating the tables of corrections (see Appendix 1).

The estimated parameters to check are the epoch, the composite Sigma, the amplitude and the slope of the logarithm of the trailing edge.

These parameters have to be compared with the corresponding parameters computed from the current nominal PTR and LPF spectrum. The estimated parameters are compared with the reference values with a permitted band of fluctuation . The reference parameters are available on an external file (its update depends on the evolution of the altimeter components).

ALGORITHM SPECIFICATION

Input data

- Validity flag of the corrected PTR : Flag_Val_Cor_PTR (/) [(1)]
- Execution flag for the estimation algorithm : Flag_Retrack (/) [(1)]
- Estimated altimetric parameters:
  - Epoch : Epoch (s)
  - Composite Sigma : SigmaC (s)
  - Amplitude : Ampl (FFT power unit)
  - Slope of the logarithm of the trailing edge : Slope (s^{-1})
- Reference altimetric parameters:
  - Epoch : Epoch_Ref (s)
  - Composite Sigma : SigmaC_Ref (s)
  - Amplitude : Ampl_Ref (FFT power unit)

[(1)] 2 states : “valid” and “invalid”

- Slope of the logarithm of the trailing edge : Slope_Ref (s^{-1})

- Lower and upper admissible deviations of the altimetric parameters:
  - Lower admissible deviation for the epoch : Low_Epoch (s)
  - Upper admissible deviation for the epoch : Upp_Epoch (s)
  - Lower admissible deviation for the composite Sigma : Low_SigmaC (s)
  - Upper admissible deviation for the composite Sigma : Upp_SigmaC (s)
  - Lower admissible deviation for the amplitude : Low_Ampl (FFT power unit)
  - Upper admissible deviation for the amplitude : Upp_Ampl (FFT power unit)
  - Lower admissible deviation for the slope of the logarithm of the trailing edge : Low_Slope (s^{-1})
  - Upper admissible deviation for the slope of the logarithm of the trailing edge : Upp_Slope (s^{-1})

Output data

- Quality flag for the estimated epoch : Flag_Epoch (/) [(1)]
- Quality flag for the estimated composite sigma : Flag_SigmaC (/) [(1)]
- Quality flag for the estimated amplitude : Flag_Ampl (/) [(1)]
- Quality flag for the estimated slope of the log. of the trailing edge : Flag_Slope (/) [(1)]
- Quality flag associated with the overall estimation process : Flag_Estimation (/) [(1)]
- Execution status

Processing

If the validity flag of the corrected PTR (Flag_Val_Cor_PTR) and the execution flag for the estimation algorithm (Flag_Retrack) are set to "valid", then the following processing must be implemented. Else, the output parameters are set to a default value.

Quality flags for each estimated parameter are issued using the mechanism (AD11) “GEN_MEC_QUA_01 - Quality check from thresholds” with the following input:

- Parameter to be checked : X
- Validity thresholds
  - ∗ Lower bound : X_Ref – Low_X (same unit as X)
  - ∗ Upper bound : X_Ref + Upp_X (same unit as X)

The output of the mechanism is the validity flag of the parameter X (2 states flag): Flag_X (/)

[(1)] 2 states : “valid” and “invalid”

The quality flag associated with the overall estimation process Flag_Estimation is set to "invalid" if at least one of the Flag_X is set to "invalid". If Flag_X is set to "valid" for all the checked parameters, then Flag_Estimation is set to "valid".

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

4. "ALT" PROCESSING

4.1. PROCESSING OVERVIEW

4.1.1. BRIEF DESCRIPTION

A brief overview of the main functions of the nominal ALT processing is given in this section. A detailed description is provided in section 4.2.

- The type of the overflown surface (4 states) is determined from a land/sea mask file.
- For each averaged measurement, the square of the platform-derived off-nadir angle is derived from the input platform data.
- For each elementary measurement, the coarse and fine trigger delays applied on-board to each pulse (Ku or C bands) are restored from the level 1.0 tracker range and tracker range rate.
- For each elementary measurement, the Ku-band and C-band tracker range estimates are computed from the restored coarse and fine trigger delays, accounting for the USO frequency drift. Moreover, the USO frequency correction on the altimeter range is computed (to be stored in the SGDR product after 1-Hz compression), and the tracker range rate is converted to distance versus time.
- The on-board retracked estimates of the altimeter range are then derived for Ku and C bands, using the on-board epoch estimates in both bands.
- The elementary Ku-band and C-band AGC values are corrected for the instrumental errors due to the imperfections of the on-board attenuators. The corresponding corrections are also provided (to be stored in the SGDR product after 1-Hz compression).
- The square of the off-nadir angle is derived from the 1-Hz on-board estimates of the total power of the Ku-band waveforms in two windows set on the trailing edge, accounting for the effect of the low-pass filter (POSEIDON-2 LTM calibration parameters).
- The following elementary estimates are edited and compressed over 1 second:
  - tracker ranges (Ku and C bands)
  - USO frequency correction on the altimeter range
  - tracker range rates
  - on-board retracked altimeter ranges (Ku and C bands)
  - corrected AGC (Ku and C bands)
  - corrections of instrumental errors on the AGC (Ku and C bands)

  Moreover, 1-Hz estimates of the on-board waveform-derived square of the off-nadir angle are computed by an averaging over N≥1 seconds.
- The 20-Hz so-called "scaling factors for Sigma0 evaluation" required to determine the backscatter coefficients from the on-ground (level 2) retracked amplitudes, and the 1-Hz so-called "scaling factor for on-board retracked Sigma0 evaluation" required to determine the backscatter coefficients from the on-board estimates of the AGC combined with the retracked amplitude of the waveforms, are computed for the Ku and C bands. These parameters account for the total power of the altimeter PTR (POSEIDON-2 LTM calibration parameters). The corresponding internal calibration corrections on the backscatter coefficients are also provided (to be stored in the SGDR product).

- The Ku-band and C-band on-board retracked backscatter coefficients are computed from the 1-Hz scaling factors for Sigma0 evaluation and from the 1-Hz on-board estimates of the AGC combined with the retracked amplitude of the waveforms.
- The signal to noise ratio (Ku and C bands) is computed from the 1-Hz on-board estimate of the AGC combined with the retracked amplitude, the 1-Hz corrected AGC and the 1-Hz thermal noise level estimates.
- The 1-Hz corrections of the impact of an antenna mispointing on the altimetric estimates (altimeter range, significant waveheight and backscatter coefficient) are computed for Ku and C bands from models depending on the significant waveheight and on the square of the off-nadir angle (interpolated platform data or possibly waveform-derived data).
- The 1-Hz modeled corrections of the instrumental errors on the altimetric estimates (altimeter range, altimeter range rate, significant waveheight and backscatter coefficient) are computed for Ku and C bands, using correction tables built from a simulator of the altimeter and from the on-board retracking algorithm (see § 2.1.2). The entries in the table are the significant waveheight and the signal to noise ratio (see Appendix A1).
- The 1-Hz internal path correction on the altimeter range is computed, accounting in particular for the difference of travel between the transmission and the reference lines within the altimeter (POSEIDON-2 LTM calibration parameter).
- The 1-Hz Doppler correction on the altimeter range is computed for Ku and C bands from the orbital altitude rate with respect to the reference ellipsoid, derived from DORIS navigator orbit (level 1.0 parameter). This correction does not take into account that the spacecraft overflows a surface with varying height. It is sufficient for the NRT error budget (see RD4 for the level 2 products).
- The Ku and C bands corrected parameters (tracker ranges, tracker range rates, on-board retracked altimeter ranges, on-board retracked significant waveheights and on-board retracked backscatter coefficients) are computed, accounting in particular for the distance antenna - COG and for system biases (see Appendix A1).
- The Ku and C band waveforms are corrected for the effect of the low-pass filtering (POSEIDON-2 LTM calibration parameters)

Thanks to the features of the thermal control of the platform (see RD13), temperatures of the altimeter components (housekeeping data) are not required in the processing of the altimeter data. The interpolation of the total power of the PTR versus the SSPA temperature, which was performed in the processing of the POSEIDON-1 data, was justified because of the frequent switches on and off of the altimeter.

The sign of the the various instrumental corrections computed in this processing is such as the corrected value of a physical parameter (altimeter range, altimeter range rate, significant waveheight, backscatter coefficient) is the sum of its raw value and of the corresponding corrections.

4.1.2. LIST OF FUNCTIONS

A list of the functions of the nominal JASON-1 ALT processing is given in **Figure 4**.

The functions defined hereafter only concern altimeter measurements in tracking mode.

FUNCTION
GEN_ENV_SUR_01 - To determine the surface type
PLA_PHY_MIS_01 - To compute the platform-derived off-nadir angle
ALT_PHY_RAN_01 - To restore the on-board coarse and fine trigger delays
ALT_PHY_RAN_02 - To compute the tracker ranges
ALT_PHY_RAN_03 - To compute the on-board retracked altimeter ranges
ALT_PHY_BAC_01 - To correct the AGC
ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates
ALT_COM_RAN_01 - To edit and compress the tracker ranges
ALT_COM_RAN_02 - To edit and compress the USO frequency correction on the altimeter range
ALT_COM_RAN_03 - To edit and compress the tracker range rates
ALT_COM_RAN_04 - To edit and compress the on-board retracked altimeter ranges
ALT_COM_BAC_01 - To edit and compress the corrected AGC
ALT_COM_BAC_02 - To edit and compress the corrections for instrumental errors on the AGC
ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived)
ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation
ALT_PHY_BAC_03 - To compute the on-board retracked backscatter coefficients
ALT_PHY_SNR_01 - To compute the SNR from the on-board estimates
ALT_COR_GEN_01 - To compute the mispointing corrections
ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters
ALT_COR_RAN_01 - To compute the internal path correction
ALT_COR_RAN_02 - To compute the Doppler correction
ALT_COR_RAN_03 - To compute the corrected tracker ranges
ALT_COR_RAN_04 - To compute the corrected on-board retracked altimeter ranges
ALT_COR_RAN_05 - To compute the corrected tracker range rates
ALT_COR_SWH_01 - To compute the corrected on-board retracked significant waveheights
ALT_COR_BAC_01 - To compute the corrected on-board retracked backscatter coefficients
ALT_COR_WAV_01 - To correct the waveforms for the filtering effects

Figure 4: Functions of the nominal JASON-1 ALT processing

4.2. FUNCTIONS

A detailed description of the functions of the nominal JASON-1 ALT processing is given in this section.

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GEN_ENV_SUR_01 - To determine the surface type

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HERITAGE

None

FUNCTION

To determine the type of the overflown surface (“open ocean or semi-enclosed seas”, “enclosed seas or lakes”, “continental ice” or “land”) from a dedicated land/sea mask file.

APPLICABILITY

JASON-1 and ENVISAT (see RD4).

ALGORITHM DEFINITION

Input data

- Product data:
  - Location (1 Hz):
    - Latitude
    - Longitude
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Land/sea mask file

Output data

- Surface type, set to “open ocean or semi-enclosed seas”, or “enclosed seas or lakes”, or “continental ice” or “land”.

Mathematical statement

The latitude and longitude of the altimeter measurement are used to determine the nearest grid point in the land/sea mask file. The surface type is thus set to the surface type reported for this nearest grid point.

ALGORITHM SPECIFICATION

For each averaged measurement, the determination of the surface type is specified hereafter.

Input data

- Location of the measurement:
  - Latitude : Lat (degree)
  - Longitude : Lon (degree [0, 360[)
- Processing parameters relative to the land/sea file:
  - Number of grid points in the longitude axis : Land_Sea_Nb_Lon (/)
  - Number of grid points in the latitude axis : Land_Sea_Nb_Lat (/)
  - Map : Land_Sea[0:Land_Sea_Nb_Lon-1, 0:Land_Sea_Nb_Lat-1] (m)
  - Latitude step : Land_Sea_Lat_Step (minute)
  - Longitude step : Land_Sea_Lon_Step (minute)
  - First latitude : Land_Sea_Lat_First (minute)
  - First longitude : Land_Sea_Lon_First (minute [0, 21600[)

Output data

- Surface type (1) : Alt_Surf_Type (/)
- Execution status

Processing

- The input latitude (Lat) and longitude (Lon) are multiplied by 60 to be expressed in minutes.
- The indexes of the four grid points surrounding the measurement are computed using the mechanism "GEN_MEC_GRI_01 - Cell identification" (AD11), with the following inputs:
  - X co-ordinate of the point : Lon (minutes)
  - Y co-ordinate of the point : Lat (minutes)
  - The grid step in X : Land_Sea_Lon_Step
  - The grid step in Y : Land_Sea_Lat_Step
  - The value of X corresponding to the first grid point : Land_Sea_Lon_First
  - The value of Y corresponding to the first grid point : Land_Sea_Lat_First
  - The number of points in X of the grid : Land_Sea_Nb_Lon
  - The number of points in Y of the grid : Land_Sea_Nb_Lat
  - The cycling value for the X variable : 21600
  - The cycling value for the Y variable : 0
  - The truncation flag for the X variable : 0

(1) 4 states: "open ocean or semi-enclosed seas", "enclosed seas or lakes", "continental ice" or "land"

- The truncation flag for the Y variable : 0

The corresponding outputs are the indexes of the four grid points surrounding the measurement point, and the corresponding weights of these grid points

- Left index in X : Ind_Lon_Left
- Right index in X : Ind_Lon_Right
- Bottom index in Y : Ind_Lat_Bottom
- Top index in Y : Ind_Lat_Top
- Weight of the lower left corner : Wll
- Weight of the lower right corner : Wlr
- Weight of the upper left corner : Wul
- Weight of the upper right corner : Wur

• To determine the nearest grid point, the point having the highest weight is selected, and then Alt_Surf_Type is set to the surface type reported at the nearest grid point.

ACCURACY

The "heritage" of DTM 2000.1 goes back to the OSUJAN89 database described by Pavlis and Rapp (Geophys. J. Int., 1990, pp. 369-378), and the JGP95E database described in Chapter 2 of the EGM96 Technical Report by Lemoine et al. (1998)

COMMENTS

None

REFERENCES

None

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31401 TOULOUSE CEDEX 4

PLA_PHY_MIS_01 - To compute the platform-derived off-nadir angle

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

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	CCM			

HERITAGE

None

FUNCTION

To compute the square of the off-nadir angle from the platform data.

APPLICABILITY

JASON-1 and ENVISAT.

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tags (1 Hz)
- Computed data: None
- Dynamic auxiliary data:
  - Platform data and associated time-tags:
    - Altimeter antenna off-nadir angle
- Static auxiliary data:
  - Processing parameter for the computation of the square of the platform-derived off-nadir angle:
    - Threshold on the square of the off-nadir angle

Output data

- Square of the off-nadir angle: ξ^2
- Validity flag for the square of the off-nadir angle

Mathematical statement

The altimeter antenna off-nadir angle corresponding to each 1-Hz input altimeter measurement is the closest value which precedes the altimeter time-tag. The square of this value is derived and a validity flag is determined using a threshold.

ALGORITHM SPECIFICATION

Warning: The selection of the antenna off-nadir angle for each altimeter time-tag is considered as a "data management" algorithm (see section 1). It is specified in RD11.

For each averaged measurement, the computation of the square of the off-nadir angle from the platform data is specified hereafter.

Input data

- Platform data (selected):
  - Altimeter antenna off-nadir angle : Alt_Off_Nad (degree)
- Processing parameter:
  - Threshold on the square of the off-nadir angle : Thresh_Off_Nad_Pf2 (degree^2)

Output data

- Square of the off-nadir angle : Off_Nad_Pf2_Mean (degree^2)
- Validity flag for the square of the off-nadir angle : Off_Nad_Pf2_Mean_Val_Flag (/)
- Execution status

Processing

- The square of the off-nadir angle is computed by:

$$Off\_Nad\_Pf2\_Mean = Alt\_Off\_Nad^2 \qquad (1)$$

- The validity flag for the square of the off-nadir angle is built as follows:
  - If $Off\_Nad\_Pf2\_Mean < Thresh\_Off\_Nad\_Pf2$, then Off_Nad_Pf2_Mean_Val_Flag is set to "valid"
  - Else, Off_Nad_Pf2_Mean_Val_Flag is set to "invalid"

ACCURACY

The off-nadir angle associated to each altimeter measurement is the closest value which precedes the altimeter time-tag. No interpolation is required due to the sampling step of platform data (1 minute).

COMMENTS

None

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_PHY_RAN_01 - To restore the on-board coarse and fine trigger delays

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To restore the coarse and fine trigger delays applied on-board to each pulse of each elementary measurement, from the level 1.0 tracker range and tracker range rate.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Tracker range (counter - 20 Hz)
  - Tracker range rate (counter - 20 Hz)
  - Tracker range validity flag
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Ratio tracker range resolution / tracker range rate resolution
    - Total number of pulses per waveform

Output data

- Coarse trigger delay (counter) applied on-board to each pulse
- Fine trigger delay (counter) applied on-board to each pulse

Mathematical statement

For each elementary measurement, the coarse and fine trigger delays applied on-board to each pulse (Ku or C band) are restored from the level 1.0 tracker range and tracker range rate, using the on-board sequencing algorithm (default values are provided in case of invalidity of the tracker range).

ALGORITHM SPECIFICATION

For each elementary measurement, the restoration of the coarse and fine trigger delays applied on-board to each pulse (Ku or C band) is specified hereafter from RD8.

Input data

- Tracker range and validity flag:
  - Tracker range (counter) : Trk_Range_Count (/)
  - Tracker range validity flag : Trk_Range_Val_Flag (/)
- Tracker range rate (counter) : Trk_Range_Rate_Count (/)
- POSEIDON-2 instrumental characterization data:
  - Total number of pulses per waveform : Nb_Pulse (/)
  - Ratio tracker range resolution / tracker range rate resolution : Ratio_Range_Rate_Res (/)

Output data

- Coarse trigger delays applied on-board (counter) : Coarse_TD [0:Nb_Pulse-1]
- Fine trigger delays applied on-board (counter) : Fine_TD [0:Nb_Pulse-1]
- Execution status

Processing

Warning: The computations performed in this algorithm must represent those which have been applied on-board. The tracker range (Trk_Range_Count) must be considered as an unsigned word of 24 bits. The ratio between the resolutions of the tracker range and of the tracker range rate (Ratio_Range_Rate_Res) is a power of 2.

- If the tracker range validity flag (Trk_Range_Val_Flag) is set to "valid", then:
  - The global trigger delays from which the coarse and fine trigger delays have been derived on-board for each pulse $j \in [0, Nb\_Pulse-1]$, are computed as follows:
    - ∗ Computation of H(j = 0) by modifying the resolution of the input tracker range (counter):

$$H(j=0) = Trk\_Range\_Count * Ratio\_Range\_Rate\_Res \quad (1)$$

    - ∗ Computation of H(j > 0) from H(j-1) and from the input tracker range rate, with the same resolution as H(j=0):

$$H(j>0) = H(j-1) + Trk\_Range\_Rate\_Count \quad (2)$$

  - For each pulse $j \in [0, Nb\_Pulse-1]$, the coarse and fine trigger delays (Coarse_TD(j) and Fine_TD(j)) applied on-board are derived by the following algorithm:
    - ∗ H(j) is rounded to the 24 most significant bits (same resolution as Trk_Range_Count)

- Then, the three bytes B1, B2, B3 such as $H(j) = 2^{16} * B1 + 2^{8} * B2 + B3$ are determined by:

$$B1 = \frac{H(j)}{2^{16}} \quad (3)$$

$$B2 = \frac{H(j) - 2^{16} * B1}{2^{8}} \quad (4)$$

$$B3 = H(j) - 2^{16} * B1 - 2^{8} * B2 \quad (5)$$

- The fine trigger delay Fine_TD(j) (signed) is obtained by:

$$Fine\_TD(j) = B3 - 2^{8} * C \quad (6)$$

where C is the Most Significant Bit of byte B3 ($C = \frac{B3}{2^{7}}$)

- The coarse trigger delay Coarse_TD(j) (unsigned) is obtained by:

$$Coarse\_TD(j) = 2^{8} * B1 + B2 + C \quad (7)$$

- Else (Trk_Range_Val_Flag set to "invalid"):

  The coarse and fine trigger delays applied on-board to the pulses of the elementary measurement (Coarse_TD(j) and Fine_TD(j), j∈[0, Nb_Pulse-1]) are set to a default value.

ACCURACY

The coarse and fine trigger delay restored values are exactly the same as those applied on-board. No error is introduced in their computation, as the on-board sequencing algorithms is exactly reproduced from the counters built on-board.

COMMENTS

None

REFERENCES

None

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ALT_PHY_RAN_02 - To compute the tracker ranges

DEFINITION, ACCURACY AND SPECIFICATION

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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

For each elementary measurement, to compute the Ku-band and C-band tracker range estimates from the restored coarse and fine trigger delays (accounting for the DORIS USO frequency drift). Moreover, the DORIS USO frequency correction on the altimeter range is computed (to be stored in the SGDR product after 1-Hz compression), and the tracker range rate is converted into distance versus time.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tags (1 Hz)
  - Altimeter configuration data
  - Tracker range rate (counter - 20 Hz)
  - Tracker range validity flag
- Computed data:
  - From "ALT_PHY_RAN_01 - To restore the on-board coarse and fine trigger delays":
    - Coarse trigger delay applied on-board to each pulse (counter): TD_c
    - Fine trigger delay applied on-board to each pulse (counter): TD_f
- Dynamic auxiliary data:
  - DORIS-derived USO frequency and associated time-tag
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Coarse trigger delay resolution expressed in time: Δt_c
    - Fine trigger delay resolution expressed in time (depends on the emitted bandwidth): Δt_f
    - Nominal DORIS USO frequency: USO_{nom}
    - Nominal pulse repetition frequency: PRF_{nom}
    - Ambiguity order: N_a

  - Tracker range rate resolution
  - Total number of pulses per waveform: N_p
  - Number of Ku-band pulses per waveform [(1)]
  - Number of C-band pulses per waveform [(1)]
- Universal constants:
  - Light velocity: c

Output data

- Ku-band tracker range (20 Hz, expressed in distance)
- C-band tracker range (20 Hz, expressed in distance)
- USO frequency correction on the altimeter range (20 Hz, expressed in distance)
- Ku-band and C-band tracker ranges validity flags (20 Hz)
- Tracker range rate (20 Hz, expressed in distance versus time)

Mathematical statement

The DORIS-derived USO frequency corresponding to each 1-Hz input altimeter measurement is the closest value which precedes the altimeter time-tag. Let USO be this value (constant over an averaged measurement).

Tracker range estimates

For each pulse, the tracker range corrected for the USO variations and expressed in distance, is computed by:

$$h_{track}^{pulse} = \frac{c}{2} \cdot \left[\left(\frac{N_a}{PRF_{nom}} + TD_c . \Delta t_c \right) \frac{USO_{nom}}{USO} + N . \Delta t_f \right] \qquad (1)$$

where (see comments):

- $N = TD_f$ for a Ku-band pulse or C-band pulse with a bandwidth of 320 MHz
- $N = \frac{TD_f}{3.2}$ converted in integer (as on-board) for a C-band pulse with a bandwidth of 100 MHz

The 20-Hz Ku-band and C-band tracker ranges (h_{track}) are then derived by an arithmetic averaging of the corresponding estimates, accounting for the altimeter configuration. Default values are provided in case of invalidity of the tracker range. Validity flags are provided for both bands.

Moreover, the 20-Hz USO frequency correction on the altimeter range (expressed in distance) is computed separately. It will be stored in the SGDR product after 1-Hz compression. This parameter is computed from the mean value $\overline{TD_c}$ of the N_p coarse trigger delays of the elementary measurement (see "Accuracy"), by:

[(1)] Depends on the Ku/C band sequencing

$$\Delta h_{USO} = \frac{c}{2}.\left(\frac{N_a}{PRF_{nom}} + \overline{TD_c}.\Delta t_c\right)\left(\frac{USO_{nom}}{USO} - 1\right) \quad (2)$$

Tracker range rate

The 20-Hz tracker range rate counters are converted into distance versus time, using the tracker range rate resolution and accounting for the nominal pulse repetition frequency corrected for the USO variations (i.e. $PRF_{nom}.USO/USO_{nom}$). Default values are provided in case on invalidity of the tracker range.

ALGORITHM SPECIFICATION

Warning: The selection of the DORIS-derived USO frequency for each altimeter time-tag is considered as a "data management" algorithm (see section 1). It is specified in RD11.

For each elementary measurement, the computation of the Ku-band and of the C-band tracker ranges and the conversion of the tracker range rate from counts into distance versus time are specified hereafter.

Input data

- DORIS-derived USO frequency (selected): : USO_Freq (Hz)
- Altimeter configuration data flags:
  - C-band transmission : C_Trans_Flag (/)
  - Bandwidth for C-band : C_Bandwidth_Flag (/)
  - Ku/C band sequencing : KuC_Seq_Flag (/)
- Trigger delays and validity flag:
  - Coarse trigger delays applied on-board (counter) : Coarse_TD [0:Nb_Pulse-1] (/)
  - Fine trigger delays applied on-board (counter) : Fine_TD [0:Nb_Pulse-1] (/)
  - Tracker range validity flag : Trk_Range_Val_Flag (/)
- Tracker range rate (counter) : Trk_Range_Rate_Count (/)
- POSEIDON-2 instrumental characterization data:
  - Coarse trigger delay resolution : Coarse_TD_Res (s)
  - Fine trigger delay resolution at 320 MHz : Fine_TD_Res_320 (s)
  - Fine trigger delay resolution at 100 MHz : Fine_TD_Res_100 (s)
  - Nominal DORIS USO frequency : USO_Freq_Nom (Hz)
  - Nominal pulse repetition frequency : PRF_Nom (Hz)
  - Ambiguity order : Amb_Order (/)
  - Tracker range rate resolution : Trk_Range_Rate_Res (s)
  - Total number of pulses per waveform : Nb_Pulse (/)

  - Number of Ku-band pulses per waveform [(1)] : Np_Trk_Ku (/)
  - Number of C-band pulses per waveform [(1)] : Np_Trk_C (/)
- Universal constants:
  - Light velocity : Light_Vel (m/s)

Output data

- Ku-band tracker range : Trk_Range_Ku (m)
- Ku-band tracker range validity flag : Trk_Range_Ku_Val_Flag (/)
- C-band tracker range : Trk_Range_C (m)
- C-band tracker range validity flag : Trk_Range_C_Val_Flag (/)
- USO frequency correction on the altimeter range : Cor_USO_Range (m)
- Tracker range rate : Trk_Range_Rate (m/s)
- Execution status

Processing

If the tracker range validity flag (Trk_Range_Val_Flag) is set to "valid", then:

- Ku-band and C-band pulses of the elementary measurement are identified as follows from the Ku/C band sequencing flag:
  - If KuC_Seq_Flag is set to “212”, then the elementary measurement consists of Nb_Pulse/5 consecutive groups of 5 pulses, and in each group Ku-band pulses are the first two ones and the last two ones, while the C-band pulse is the third one.
  - If KuC_Seq_Flag is set to “313”, then the elementary measurement consists of Nb_Pulse/7 consecutive groups of 7 pulses, and in each group Ku-band pulses are the first three ones and the last three ones, while the C-band pulse is the fourth one.
- The Ku-band tracker range Trk_Range_Ku (m) is computed from the following steps:
  - For each Ku-band pulse j (Np_Trk_Ku pulses, with j ∈ [0, Nb_Pulse-1]), the combined trigger delay Comb_TD(j) (s) is computed by:

$$\begin{aligned}\mathrm{Comb\_TD(j)} &= \mathrm{Coarse\_TD(j)} * \mathrm{Coarse\_TD\_Res} * \frac{\mathrm{USO\_Freq\_Nom}}{\mathrm{USO\_Freq}} \\ &+ \mathrm{Fine\_TD(j)} * \mathrm{Fine\_TD\_Res\_320}\end{aligned} \quad (1)$$

[(1)] Value to be selected according to the Ku/C band sequencing (altimeter configuration data)

- The elementary combined trigger delay Comb_TD_Ku (s) is computed using mechanism "GEN_MEC_COM_01 - Arithmetic Averaging" (AD11), with the following inputs:
  - Number of Ku-band pulses : Np_Trk_Ku (/)
  - Corresponding Ku-band combined trigger delays : {Comb_TD(j)}
- The Ku-band tracker range is given by:

$$Trk\_Range\_Ku = \frac{Light\_Vel}{2} * \left(\frac{Amb\_Order}{PRF\_Nom} * \frac{USO\_Freq\_Nom}{USO\_Freq} + Comb\_TD\_Ku \right) \quad (2)$$

- The Ku-band tracker range validity flag (Trk_Range_Ku_Val_Flag) is set to "valid"

• The C-band tracker range Trk_Range_C (m) is computed from the following steps:
  - If the C-band transmission flag (C_Trans_Flag) is set to “C-band transmitted”, then:
    - If the flag indicating the bandwidth used for C band (C_Bandwidth_Flag) is set to "320 MHz", the combined trigger delay is computed for each C-band pulse j (Np_Trk_C pulses, with j ∈ [0, Nb_Pulse-1]), using (1).

      Else (C_Bandwidth_Flag set to "100 MHz"), the combined delay is computed for each C-band pulse j (Np_Trk_C pulses, with j ∈ [0, Nb_Pulse-1]), by:

$$\begin{aligned} Comb\_TD(j) &= Coarse\_TD(j) * Coarse\_TD\_Res * \frac{USO\_Freq\_Nom}{USO\_Freq} \\ &+ I\left[\frac{Fine\_TD(j)}{3.2}\right] * Fine\_TD\_Res\_100 \end{aligned} \quad (3)$$

      where I represents the integer conversion used on-board (TBC integer truncation)
    - The elementary combined trigger delay Comb_TD_C (s) is computed using mechanism “GEN_MEC_COM_01 - Arithmetic averaging" (AD11), with the following inputs:
      - ◊ Number of C-band pulses : Np_Trk_C (/)
      - ◊ Corresponding C-band combined trigger delays : {Comb_TD(j)}
    - The C-band tracker range is given by:

$$Trk\_Range\_C = \frac{Light\_Vel}{2} * \left(\frac{Amb\_Order}{PRF\_Nom} * \frac{USO\_Freq\_Nom}{USO\_Freq} + Comb\_TD\_C \right) \quad (4)$$

    - The C-band tracker range validity flag (Trk_Range_C_Val_Flag) is set to "valid"
  - Else (C_Trans_Flag set to “C-band not transmitted”):
    - The C-band tracker range (Tracker_Range_C) is set to a default value
    - The validity flag for the C-band tracker range (Trk_Range_C_Val_Flag) is set to "invalid"

- The USO frequency correction on the altimeter range Cor_USO_Range (m) is computed from the following steps:
  - The elementary coarse trigger delay Coarse_TD_Elem is computed using mechanism "GEN_MEC_COM_01 - Arithmetic Averaging" (AD11), with the following inputs:
    - Total number of pulses : Nb_Pulse (/)
    - Corresponding combined trigger delays : {Coarse_TD(j)}
  - The USO frequency correction is then computed by:

$$Cor\_USO\_Range = \frac{Light\_Vel}{2} * \left(\frac{USO\_Freq\_Nom}{USO\_Freq} - 1 \right) * \left(\frac{Amb\_Order}{PRF\_Nom} + Coarse\_TD\_Elem * Coarse\_TD\_Res \right) \quad (5)$$

- The tracker range rate is converted into distance versus time by:

$$Trk\_Range\_Rate = Trk\_Range\_Rate\_Count * Trk\_Range\_Rate\_Res * PRF\_Nom * \frac{USO\_Freq}{USO\_Freq\_Nom} * \frac{Light\_Vel}{2} \quad (6)$$

Else (Trk_Range_Val_Flag set to "invalid"):

- The Ku-band and C-band tracker ranges (Trk_Range_Ku and Trk_Range_C) are set to a default value
- The USO frequency correction on the altimeter range (Cor_USO_Range) is set to a default value
- The validity flags for the Ku-band and C-band tracker ranges (Trk_Range_Ku_Val_Flag and Trk_Range_C_Val_Flag) are set to "invalid"
- The converted tracker range rate (Trk_Range_Rate) is set to a default value

ACCURACY

- The DORIS-derived USO frequency associated to each altimeter measurement is the closest value which precedes the altimeter time-tag. No interpolation is required due to the sampling step of USO data (6 hours).
- Two values of the 20-Hz USO frequency correction on the altimeter range should normally be computed: one for the Ku-band pulses and one for the C-band pulses. A single computation from the whole set of pulses may be performed, because on one hand the coarse trigger delays computed on-board for the Ku-band and the C-band pulses are issued from the same algorithm (tracking function) which operates in Ku-band, and because on the other hand of the symmetry of the Ku/C band sequencing ("313" or "212").

COMMENTS

- Despite the symmetry of the Ku/C bands sequencing, the tracker range estimates may not be identical for Ku band and for C band with a 100-MHz bandwidth, due to the difference of resolution of the fine trigger delay (see RD6).

  The computed fine trigger delay to be applied to a pulse is a counter N (signed integer), representing a multiple of 1/64 FFT samples in the Ku bandwidth of 320 MHz as it is derived from Ku-band waveforms.

In the case of a Ku-band pulse or a C-band pulse with a bandwidth of 320 MHz, the applied fine trigger delay (x_{320} expressed in time) will be:

$$x_{320} = N * \frac{\Delta t_{320}}{64} \qquad \text{with: } \Delta t_{320} = \text{FFT step at 320 MHz} = 3.125 \text{ ns}$$

However if the pulse is a C-band pulse with a bandwidth of 100 MHz, then the applied fine trigger delay (x_{100}) will account for the factor of 3.2 on the fine trigger delay resolution (1/64 FFT step at 100 MHz instead of 1/64 FFT step at 320 MHz). It will thus be:

$$x_{100} = M * \frac{\Delta t_{100}}{64} \qquad \text{with: } \Delta t_{100} = \text{FFT step at 100 MHz} = 3.2 * 3.125 = 10 \text{ ns}$$

where $M = \frac{N}{3.2}$, to be converted in integer (signed).

REFERENCES

None

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ALT_PHY_RAN_03 - To compute the on-board retracked altimeter ranges

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

For each elementary measurement, to compute the Ku-band and C-band on-board retracked estimates of the altimeter range.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Ku-band on-board retracked epoch (20 Hz - expressed in distance)
  - C-band on-board retracked epoch (20 Hz - expressed in distance)
  - Ku-band and C-band on-board retracked epoch validity flags
- Computed data:
  - From "ALT_PHY_RAN_02 - To compute the tracker ranges":
    - Ku-band tracker range (20 Hz, expressed in distance)
    - C-band tracker range (20 Hz, expressed in distance)
    - Ku-band and C-band tracker range validity flags
- Dynamic auxiliary data: None
- Static auxiliary data: None

Output data

- Ku-band on-board retracked altimeter range (20 Hz, expressed in distance)
- C-band on-board retracked altimeter range (20 Hz, expressed in distance)
- Ku-band and C-band on-board retracked altimeter range validity flags

Mathematical statement

The 20-Hz Ku-band and C-band on-board retracked altimeter range estimates ($h_{retrack}$) are derived from the corresponding tracker range estimates (h_{track}) and on-board retracked epoch estimates (τ) by:

$$h_{retrack} = h_{track} + \tau \qquad (1)$$

The validity of the on-board retracked altimeter ranges is determined from the tracker range validity flags and the on-board retracked epoch validity flags. Default values are provided in case of invalidity of the on-board retracked altimeter range estimates.

ALGORITHM SPECIFICATION

For each elementary measurement, the computation of the on-board retracked altimeter range and of the corresponding validity flag (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Tracker range and validity flag [Ku/C]:
  - Tracker range : Trk_Range (m)
  - Tracker range validity flag (1) : Trk_Range_Val_Flag (/)
- On-board retracked epoch and validity flag [Ku/C]:
  - On-board retracked epoch : Epoch (m)
  - On-board retracked epoch validity flag (1) : Epoch_Val_Flag (/)

Output data

- On-board retracked altimeter range [Ku/C] : Retrk_Range (m)
- On-board retracked altimeter range validity flag [Ku/C] (1) : Retrk_Range_Val_Flag (/)
- Execution status

Processing

The on-board retracked altimeter range and the associated validity flag are computed using mechanism "GEN_MEC_COR_01 - Computation of a tracking/retracking combined parameter" (AD11), with the following inputs:

- Tracking-derived parameter : Trk_Range
- Tracking-derived parameter validity flag : Trk_Range_Val_Flag
- Retracking-derived parameter : Epoch
- Retracking-derived parameter validity flag : Epoch_Val_Flag
- Type of conversion for the retracking-derived parameter : set to "none"

(1) 2 states: "valid" and "invalid"

- Light velocity : not requested

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

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ALT_PHY_BAC_01 - To correct the AGC

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To correct the elementary Ku-band and C-band AGC values for the instrumental errors, and to provide the corresponding corrections (to be stored in the SGDR product after 1-Hz compression).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Ku-band AGC (20 Hz)
  - C-band AGC (20 Hz)
  - Tracker AGC validity flags
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Ku-band AGC correction table (applied value versus transmitted value)

Output data

- Ku-band corrected AGC (20 Hz)
- Correction for instrumental errors on the Ku-band AGC (20 Hz)
- C-band corrected AGC (20 Hz)
- Correction for instrumental errors on the C-band AGC (20 Hz)

Mathematical statement

For each elementary measurement, the Ku-band and C-band AGC values are used to access the table which correct for the instrumental errors due to the imperfections of the on-board attenuators. This table provide the corresponding corrected values. The corresponding corrections are derived by removing the raw value from the corrected value. This process is applied to the valid estimates only.

ALGORITHM SPECIFICATION

For each elementary measurement, the computation of the corrected AGC and of the corresponding corrections (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- AGC and validity flags [Ku/C] :
  - AGC (raw value, integer) : AGC_Raw (dB)
  - Tracker AGC validity flag (1) : Trk_AGC_Val_Flag (/)
- POSEIDON-2 instrumental characterization data:
  - AGC correction table:
    - Corrected AGC values : AGC_Corr [0:61] (dB)

Output data

- Corrected AGC [Ku/C] : AGC (dB)
- Correction for instrumental errors on AGC [Ku/C] : Cor_Instr_AGC (dB)
- Execution status

Processing

- If the tracker AGC validity flag (Trk_AGC_Val_Flag) is set to "valid", then:
  - The corrected AGC value (AGC) is obtained by:

$$AGC = AGC\_Corr(AGC\_Raw) \tag{1}$$

  - The corresponding correction (Cor_Instr_AGC) is derived by:

$$Cor\_Instr\_AGC = AGC - AGC\_Raw \tag{2}$$

- Else (Trk_AGC_Val_Flag set to "invalid"), then the corrected tracker AGC (AGC) and the corresponding correction (Cor_Instr_AGC) are set to default values.

---

(1) 2 states: "valid" and "invalid"

ACCURACY

The corrected AGC will exactly represent the value applied on-board.

COMMENTS

None

REFERENCES

None

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ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates

DEFINITION, ACCURACY AND SPECIFICATION

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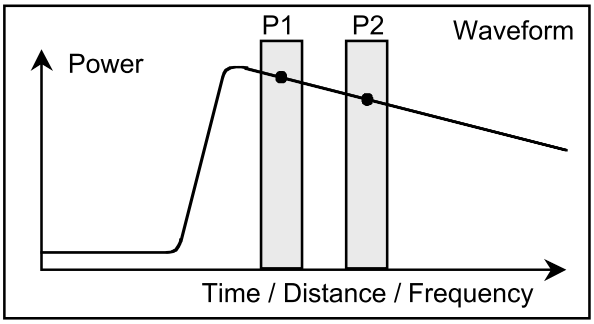
Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To derive the square of the off-nadir angle from the 1-Hz on-board estimates of the total power of the Ku-band waveforms in two fixed windows on the trailing edge, accounting for the effect of the low-pass filter.



APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tag (1 Hz)
  - Ku-band total power of the waveform in the first window of the trailing edge (1 Hz): P_1
  - Ku-band total power of the waveform in the second window of the trailing edge (1 Hz): P_2
  - Ku-band thermal noise level (1 Hz): P_{NT}
  - Validity flags:
    - for the Ku-band thermal noise level (1 Hz)
    - for the Ku-band total power of the waveform in the first window (1 Hz)
    - for the Ku-band total power of the waveform in the second window (1 Hz)
- Computed data: None

- Dynamic auxiliary data:
  - Time-stamped POSEIDON-2 LTM calibration parameters (LPF):
    - Factor representing the mean filter effect in the window used to compute P_1: f_1
    - Factor representing the mean filter effect in the window used to compute P_2: f_2
    - Factor representing the mean filter effect in the window used to compute P_{NT}: f_{NT}
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of samples used to compute P_1: N_1
    - Number of samples used to compute P_2: N_2
    - Number of samples used to compute P_{NT}: N_{NT}
    - Antenna beamwidth (at 3 dB) for Ku band: θ_0
    - Time interval between the two windows on the trailing edge: Δt
  - Processing parameters:
    - Mean satellite altitude: h_{ref}
    - Threshold on the square of the off-nadir angle
  - Universal constants:
    - Light velocity: c
    - Earth radius: R_e

Output data

- Square of the off-nadir angle (1 Hz)
- Validity flag for the square of the off-nadir angle (1 Hz)

Mathematical statement

Principle

The basic principle from which the computation of the square of the off-nadir angle is derived is the following. Assuming a gaussian point target response, the mean return power model (Ref. 1) is given by:

$$V(t) = a_\xi \frac{P_u}{2} e^{-v} \left\{ f(u) + \frac{\lambda_s}{6}\left(\frac{\sigma_s}{\sigma_c}\right)^3 \left\{ f(u) c_\xi^3 \sigma_c^3 - \sqrt{\frac{2}{\pi}} \left[2u^2 + 3\sqrt{2} c_\xi \sigma_c u + 3 c_\xi^2 \sigma_c^2 - 1\right] e^{-u^2} \right\} \right\} + P_n \quad (1)$$

accounting for the notations defined in the input data section, and with:

$$f(x) = 1 + \mathrm{erf}(x), \ \mathrm{erf}(x) = \frac{2}{\sqrt{\pi}} . \int_0^x e^{-t^2} dt \quad (2)$$

$$\gamma = \frac{2}{\mathrm{Log}_e(2)}.\sin^2(\frac{\theta_0}{2})\ ,\ \alpha = \frac{4c}{\gamma h_{ref}\left(1+\frac{h_{ref}}{R_e}\right)} \tag{3}$$

$$\sigma p = \text{PTR width}\ ,\ SWH = 2\,c\,\sigma_s\ ,\ \sigma_c^2 = \sigma_p^2 + \sigma_s^2 \tag{4}$$

$$a_\xi = \exp\left(\frac{-4\sin^2\xi}{\gamma}\right),\ b_\xi = \cos(2\xi) - \frac{\sin^2(2\xi)}{\gamma}\ ,\ c_\xi = b_\xi\alpha \tag{5}$$

$$u = \frac{t-\tau-c_\xi\sigma_c^2}{\sqrt{2}\sigma_c}\ \ ,\ v = c_\xi\left(t-\tau-\frac{c_\xi\sigma_c^2}{2}\right) \tag{6}$$

τ	= epoch of the waveform
SWH	= significant waveheight
P_u	= amplitude of the waveform
P_n	= thermal noise level
λ_s	= skewness coefficient
ξ	= off-nadir angle

Ignoring the skewness effect, the trailing edge of the mean return power model may be represented by:

$$V(t) = a_\xi P_u e^{-v} + P_n \tag{7}$$

Assuming the knowledge of two samples $V_1=V(t_1)$ and $V_2=V(t_2)$ on the trailing edge, b_ξ may be determined by:

$$b_\xi = \frac{\log_e\left(\frac{V_1-P_n}{V_2-P_n}\right)}{\alpha\Delta t}\ \ ,\ \Delta t = t_2 - t_1 \tag{8}$$

Accounting only for the first and second order terms in the development in Taylor / Mac Laurin series of b_ξ, the estimate of the square of the off-nadir angle is thus given by:

$$\xi^2 \approx \frac{1}{2\left(1+\frac{2}{\gamma}\right)}\left[1-\frac{\mathrm{Log}_e\left(\frac{V_1-P_n}{V_2-P_n}\right)}{\alpha\Delta t}\right] \tag{9}$$

Estimation of the square of the off-nadir angle

For each averaged measurement, the LTM calibration parameters to be used are selected (calibration point just before the measurement time-tag), and the square of the off-nadir angle is derived using (9), accounting for the filter effects, i.e. with:

$$V_1 = \frac{P_1}{N_1 f_1} \text{ , } V_2 = \frac{P_2}{N_2 f_2} \text{ , } P_n = \frac{P_{NT}}{N_{NT} f_{NT}} \qquad (10)$$

The input validity flags are managed in this computation, and an output validity flag is built (threshold).

ALGORITHM SPECIFICATION

Warning: The selection of the LTM calibration parameters to be used for each averaged measurement is considered as a "data management" algorithm (see section 1). It is specified in RD11.

For each averaged measurement, the estimation and check of the square of the off-nadir angle are specified hereafter.

Input data

- Total power of the waveform and validity flags:
  - Ku-band total power of the waveform in the 1st window of the trailing edge : PTE1_Ku (FFT power unit)
  - Ku-band total power of the waveform in the 2nd window of the trailing edge : PTE2_Ku (FFT power unit)
  - Validity flag for the Ku-band total power of the waveform in the 1st window : PTE1_Ku_Val_Flag (/)
  - Validity flag for the Ku-band total power of the waveform in the 2nd window : PTE2_Ku_Val_Flag (/)
- Thermal noise level and validity flag:
  - Ku-band thermal noise level : Noise_Ku (FFT power unit)
  - Validity flag for the Ku-band thermal noise level : Noise_Ku_Val_Flag (/)
- POSEIDON-2 LTM selected calibration parameters for the Ku band (LPF):
  - Mean filter effect in the 1st window of the trailing edge : LPF_PTE1_Ku (/)
  - Mean filter effect in the 2nd window of the trailing edge : LPF_PTE2_Ku (/)
  - Mean filter effect in the thermal noise window : LPF_Noise_Ku (/)

- POSEIDON-2 instrumental characterization data:
  - Number of samples used to compute the Ku-band total power of the waveform in the 1st window of the trailing edge : Nb_PTE1_Ku (/)
  - Number of samples used to compute Ku-band total power of the waveform in the 2nd window of the trailing edge : Nb_PTE2_Ku (/)
  - Number of samples used to compute the Ku-band thermal noise level : Nb_Noise_Ku (/)
  - Antenna beamwidth for Ku band (at 3 dB) : Ant_Beam_Ku (degree)
  - Time interval between the two windows on the trailing edge : Time_Win_TE (s)
- Universal constants:
  - Light velocity : Light_Vel (m/s)
  - Earth radius : Earth_Rad (m)
- Processing parameters:
  - Mean satellite altitude : Sat_Alt (m)
  - Threshold on the square of the off-nadir angle derived from on-board estimates : Thresh_Off_Nad_Wf2 (degree^2)

Output data

- Square of the off-nadir angle : Off_Nad_Wf2 (degree^2)
- Validity flag for the square of the off-nadir angle : Off_Nad_Wf2_Val_Flag (/)
- Execution status

Processing

- If the three following conditions are satisfied:
  - PTE1_Ku_Val_Flag is set to "valid"
  - PTE2_Ku_Val_Flag is set to "valid"
  - Noise_Ku_Val_Flag is set to "valid"

  then:
  - The square of the off-nadir angle (Off_Nad_Wf2) is computed according to:

    Computation of "Gamma" and "Alpha" parameters (Gamma_Ku and Alpha_Ku, which do not vary from one measurement to an other) using mechanism "GEN_MEC_MOD_04 - Computation of "Gamma" and "Alpha" altimeter parameters" (AD11), from Ant_Beam_Ku, Sat_Alt, Earth_Rad and Light_Vel.

$$V1 = \frac{PTE1\_Ku}{Nb\_PTE1\_Ku * LPF\_PTE1\_Ku} \quad (1)$$

$$V2 = \frac{PTE2\_Ku}{Nb\_PTE2\_Ku * LPF\_PTE2\_Ku} \quad (2)$$

$$Pn = \frac{Noise\_Ku}{Nb\_Noise\_Ku * LPF\_Noise\_Ku} \quad (3)$$

$$Slope = \frac{Log_e\left(\frac{V2 - Pn}{V1 - Pn}\right)}{Time\_Win\_TE} \quad (4)$$

- Off_Nad_Wf2 (degree^2) is computed using mechanism "GEN_MEC_CON_02 - Derivation of the square of the off-nadir angle from the slope of the trailing edge" (AD11), with the following inputs:
  - Gamma instrumental parameter : Gamma_Ku (/)
  - Alpha instrumental parameter : Alpha_Ku (s^{-1})
  - Slope of the logarithm of the trailing edge : Slope (s^{-1})
  - Flags (retracking execution and slope computation) : set to "valid"
- The validity flag for the square of the off-nadir angle is then built as follows:
  - If $|Off\_Nad\_Wf2| < Thresh\_Off\_Nad\_Wf2$, then Off_Nad_Wf2_Val_Flag is set to "valid"
  - Else, Off_Nad_Wf2_Val_Flag is set to "invalid"

- Else (at least one flag among PTE1_Ku_Val_Flag, PTE2_Ku_Val_Flag and Noise_Ku_Val_Flag is set to "invalid"):
  - The square of the off-nadir angle (Off_Nad_Wf2) is set to a default value
  - The validity flag for the square of the off-nadir angle (Off_Nad_Wf2_Val_Flag) is set to "invalid"

ACCURACY

Regarding the restoration of the square of the off-nadir angle from the on-board measured parameters, the limitation due to mean return power model and in particular to the non accounting for the skewness effects on the trailing edge, may be considered as negligible (TBC). The limitation due to the accounting for the first and second order terms only in the development in Taylor / Mac Laurin series performed from (8), may also be considered as negligible (TBC).

COMMENTS

None

REFERENCES

- **Ref. 1:** Hayne G.S. 1980: "Radar Altimeter Mean Return Waveforms from Near-Normal-Incidence Ocean Surface Scattering". IEEE Trans. on antennas and propagation, Vol. AP-28, n°5, pp. 687-692.

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ALT_COM_RAN_01 - To edit and compress the tracker ranges

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

Document ref:	SMM-ST-M2-EA-11003-CN	18th October, 2001	Issue: 3	Update: 2

Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the tracker ranges (Ku and C bands) from elementary estimates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_RAN_02 - To compute the tracker ranges":
    - Ku-band tracker range (20 Hz, expressed in distance)
    - C-band tracker range (20 Hz, expressed in distance)
    - Tracker range validity flags (Ku and C bands)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement
  - Processing parameters, i.e. for each parameter:
    - Type of compression
    - Minimum number of estimates requested for the compression
    - Minimum value of the standard deviation for outliers identification
    - Standard deviation scale factor for outliers identification
    - Center of the averaged measurement

Output data

- For each parameter (Ku and C bands tracker ranges):

- Compressed value (1 Hz)
- Standard deviation
- Updated quality information

Mathematical statement

The compression process is performed from the valid elementary estimates. It consists of a linear regression, based either on the absolute deviation method (nominal solution) or on the Least Square method.

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the elementary residuals (estimate - model) with the value of the standard deviation of the elementary estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected elementary estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

For each averaged measurement, the editing and compression of the elementary estimates of the tracker ranges (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Tracker range parameters [Ku/C]:
  - Elementary estimates : Trk_Range [0:Ne -1] (m)
  - Validity flags (1) : Trk_Range_Val_Flag [0:Ne -1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)
- Editing and compression parameters [Ku/C] (2):
  - Type of compression (3) : Type_Comp_Trk_Range (/)
  - Minimum number of estimates requested for the compression : Min_Pts_Trk_Range (/)
  - Minimum value of the standard deviation for outliers identification : Min_Std_Trk_Range (m)

---

(1) 2 states: "valid" or "invalid"

(2) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

(3) One state among the 2 following : "linear regression / absolute deviation method" or "linear regression / least square method"

- Standard deviation scale factor for outliers identification : Scale_Trk_Range (/)
- Center of the averaged measurement : Center_Av_Meas (/)

Output data

- The following parameters for the tracker range [Ku/C]:
  - Compressed estimate : Trk_Range_Mean (m)
  - Standard deviation : Trk_Range_Std (m)
  - Map of valid estimates (4) : Trk_Range_Map [0:Ne-1] (/)
  - Number of valid estimates : Trk_Range_Nval (/)
  - Validity of the compressed estimate (1) : Trk_Range_Mean_Val_Flag (/)
- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Ne
- Estimates : Trk_Range [0:Ne -1]
- Map of estimates to be compressed : set to "valid" for each of the Ne estimates
- Validity flags for the estimates : Trk_Range_Val_Flag [0:Ne -1]
- Processing parameters :
  - Type of compression : Type_Comp_Trk_Range
  - Minimum number of estimates requested for the compression : Min_Pts_Trk_Range
  - Minimum value of the standard deviation for outliers identification : Min_Std_Trk_Range
  - Standard deviation scale factor for outliers identification : Scale_Trk_Range
  - Center of the averaged measurement : Center_Av_Meas

ACCURACY

For the tracker range, a linear regression is requested because of the high altitude rate (maximum value about 15 m/s). A parabolic regression is not recommended because the noise of the 20-Hz estimates is usually greater than the signal induced by the acceleration. The parabolic regression has been tested by JPL for TOPEX measurements, but it has not been retained because of the instability of the second order coefficient (acceleration).

(4) 2 states for each point of the map: "valid" or "invalid"

COMMENTS

None

REFERENCES

None

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ALT_COM_RAN_02 - To edit and compress the USO frequency correction on the altimeter range

DEFINITION, ACCURACY AND SPECIFICATION

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Approved by:	P. VINCENT CNES	

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the USO frequency correction on the altimeter range (to be stored in the SGDR product).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Tracker range validity flags (20 Hz)
- Computed data:
  - From "ALT_PHY_RAN_02 - To compute the tracker ranges":
    - USO frequency corrections on the altimeter range (20 Hz, expressed in distance)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement
  - Processing parameters:
    - Type of compression
    - Minimum number of estimates requested for the compression
    - Minimum value of the standard deviation for outliers identification
    - Standard deviation scale factor for outliers identification
    - Center of the averaged measurement

Output data

- For the USO frequency correction on the altimeter range:
  - Compressed value (1 Hz)

- Standard deviation
- Updated quality information

Mathematical statement

The compression process is performed from the valid elementary estimates. It consists of a linear regression, based either on the absolute deviation method (nominal solution) or on the Least Square method.

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the elementary residuals (estimate - model) with the value of the standard deviation of the elementary estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected elementary estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

For each averaged measurement, the editing and compression of the elementary estimates of the USO frequency correction on the altimeter range is specified hereafter.

Input data

- USO frequency correction on the altimeter range : Cor_USO_Range [0:Ne -1] (m)
- Tracker range validity flags [(1)] : Trk_Range_Val_Flag [0:Ne -1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)
- Editing and compression parameters:
  - Type of compression [(2)] : Type_Comp_Cor_USO (/)
  - Minimum number of estimates requested for the compression : Min_Pts_Cor_USO (/)
  - Minimum value of the standard deviation for outliers identification : Min_Std_Cor_USO (m)
  - Standard deviation scale factor for outliers identification : Scale_Cor_USO (/)
  - Center of the averaged measurement : Center_Av_Meas (/)

Output data

- The following parameters for the USO frequency correction on the altimeter range:
  - Compressed estimate : Cor_USO_Range_Mean (m)

---

(1) 2 states: "valid" or "invalid"

(2) One state among the 2 following : "linear regression / absolute deviation method" or "linear regression / least square method"

- Standard deviation : Cor_USO_Range_Std (m)
- Map of valid estimates (3) : Cor_USO_Range_Map [0:Ne-1] (/)
- Number of valid estimates : Cor_USO_Range_Nval (/)
- Validity of the compressed estimate (1) : Cor_USO_Range_Mean_Val_Flag (/)

- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Ne
- Estimates : Cor_USO_Range [0:Ne -1]
- Map of estimates to be compressed : set to "valid" for each of the Ne estimates
- Validity flags for the estimates : Trk_Range_Val_Flag [0:Ne -1]
- Processing parameters :
  - Type of compression : Type_Comp_Cor_USO
  - Minimum number of estimates requested for the compression : Min_Pts_Cor_USO
  - Minimum value of the standard deviation for outliers identification : Min_Std_Cor_USO
  - Standard deviation scale factor for outliers identification : Scale_Cor_USO
  - Center of the averaged measurement : Center_Av_Meas

ACCURACY

Because of the possible differences in the editing process of the 20-Hz Ku/C-band tracker ranges and of the 20-Hz USO frequency corrections on the altimeter range (due for example to the processing parameters involved in these computations), two 1-Hz USO frequency corrections should be computed: one Ku-band correction, which should account for the elementary estimates used to compute the 1-Hz Ku-band tracker range, and one C-band correction, which should account for the elementary estimates used to compute the 1-Hz C-band tracker range (using the map of valid points output by "ALT_COM_RAN_01 - To edit and compress the tracker ranges").

Nevertheless, no significant inconsistency should be observed between the 1-Hz Ku (or C) band tracker ranges and a single 1-Hz USO frequency correction independently computed.

Indeed, assuming for example the accounting for an important outlier corresponding to an error Δ=1 km in the computation of the USO frequency correction, and assuming the rejection of the corresponding outlier in the computation of the tracker ranges, the error on the USO frequency correction, $\varepsilon = \Delta.(USO_{nom}/USO - 1)$, remains smaller than 0.1 mm (and thus not significant) if $USO_{nom}/USO - 1 < 10^{-7}$, which TBC is consistent with the expected stability of the oscillator.

---

(3) 2 states for each point of the map: "valid" or "invalid"

COMMENTS

None

REFERENCES

None

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ALT_COM_RAN_03 - To edit and compress the tracker range rates

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the tracker range rate from elementary estimates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Tracker range validity flag
- Computed data:
  - From "ALT_PHY_RAN_02 - To compute the tracker ranges":
    - Tracker range rate (20 Hz, expressed in distance versus time)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement
  - Processing parameters:
    - Minimum value of the standard deviation for outliers identification
    - Minimum number of estimates requested for the compression
    - Standard deviation scale factor for outliers identification

Output data

- For the tracker range rate:
  - Compressed value (1 Hz)
  - Standard deviation
  - Updated quality information

Mathematical statement

The compression process is performed from the valid elementary estimates, which are identified from the input level 1.0 tracker range validity flags. It consists of an arithmetic averaging.

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the elementary residuals (estimate - model) with the value of the standard deviation of the elementary estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected elementary estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

For each averaged measurement, the editing and compression of the elementary estimates of the tracker range rates is specified hereafter.

Input data

- Tracker range rate parameters:
  - Elementary estimates : Trk_Range_Rate [0:Ne -1] (m/s)
  - Validity flags [(1)] : Trk_Range_Val_Flag [0:Ne -1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)
- Editing and compression parameters:
  - Minimum number of estimates requested for the compression : Min_Pts_Trk_Range_Rate (/)
  - Minimum value of the standard deviation for outliers identification : Min_Std_Trk_Range_Rate (m/s)
  - Standard deviation scale factor for outliers identification : Scale_Trk_Range_Rate (/)

Output data

- The following parameters for the tracker range rate:
  - Compressed estimate : Trk_Range_Rate_Mean (m/s)
  - Standard deviation : Trk_Range_Rate_Std (m/s)
  - Map of valid estimates [(2)] : Trk_Range_Rate_Map [0:Ne-1] (/)
  - Number of valid estimates : Trk_Range_Rate_Nval (/)
  - Validity of the compressed estimate [(1)] : Trk_Range_Rate_Mean_Val_Flag (/)

---

(1) 2 states: "valid" or "invalid"

(2) 2 states for each point of the map: "valid" or "invalid"

- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Ne
- Estimates : Trk_Range_Rate [0:Ne -1]
- Map of estimates to be compressed : set to "valid" for each of the Ne estimates
- Validity flags for the estimates : Trk_Range_Val_Flag [0:Ne -1]
- Processing parameters :
  - Type of compression : set to "arithmetic averaging"
  - Minimum number of estimates requested for the compression : Min_Pts_Trk_Range_Rate
  - Minimum value of the standard deviation for outliers identification : Min_Std_Trk_Range_Rate
  - Standard deviation scale factor for outliers identification : Scale_Trk_Range_Rate
  - Center of the averaged measurement : not requested

ACCURACY

The arithmetic averaging is the most appropriate method, due to the low variation of the signal over one second.

COMMENTS

None

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_COM_RAN_04 - To edit and compress the on-board retracked altimeter ranges

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
Checked by:	For the JASON-1 SWT M. SROKOSZ E. RODRIGUEZ For the JASON-1 Project P. VINCENT CNES S. DESAI JPL	
Approved by:	P. VINCENT CNES	

Document ref:	SMM-ST-M2-EA-11003-CN	18th October, 2001	Issue: 3	Update: 2

Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the on-board retracked altimeter ranges (Ku and C bands) from elementary estimates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_RAN_03 - To compute the on-board retracked altimeter ranges":
    - Ku-band on-board retracked altimeter range (20 Hz, expressed in distance)
    - C-band on-board retracked altimeter range (20 Hz, expressed in distance)
    - On-board retracked altimeter range validity flag (Ku and C bands)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement
  - Processing parameters, i.e. for each parameter:
    - Type of compression
    - Minimum number of estimates requested for the compression
    - Minimum value of the standard deviation for outliers identification
    - Standard deviation scale factor for outliers identification
    - Center of the averaged measurement

Output data

- For each parameter (Ku and C bands on-board retracked altimeter ranges):
  - Compressed value (1 Hz)
  - Standard deviation
  - Updated quality information

Mathematical statement

The compression process is performed from the valid elementary estimates. It consists of a linear regression, based either on the absolute deviation method (nominal solution) or on the Least Square method.

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the elementary residuals (estimate - model) with the value of the standard deviation of the elementary estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected elementary estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

For each averaged measurement, the editing and compression of the elementary estimates of the on-board retracked altimeter ranges (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- On-board retracked altimeter range parameters [Ku/C]:
  - Elementary estimates : Retrk_Range [0:Ne -1] (m)
  - Validity flags (1) : Retrk_Range_Val_Flag [0:Ne -1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)
- Editing and compression parameters [Ku/C] (2):
  - Type of compression (3) : Type_Comp_Retrk_Range (/)

(1) 2 states: "valid" or "invalid"

(2) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

(3) One state among the 2 following : "linear regression / absolute deviation method" or "linear regression / least square method"

- Minimum number of estimates requested for the compression : Min_Pts_Retrk_Range (/)
- Minimum value of the standard deviation for outliers identification : Min_Std_Retrk_Range (m)
- Standard deviation scale factor for outliers identification : Scale_Retrk_Range (/)
- Center of the averaged measurement : Center_Av_Meas (/)

Output data

- The following parameters for the on-board retracked altimeter range [Ku/C]:
  - Compressed estimate : Retrk_Range_Mean (m)
  - Standard deviation : Retrk_Range_Std (m)
  - Map of valid estimates (4) : Retrk_Range_Map [0:Ne-1] (/)
  - Number of valid estimates : Retrk_Range_Nval (/)
  - Validity of the compressed estimate (1) : Retrk_Range_Mean_Val_Flag (/)
- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Ne
- Estimates : Retrk_Range [0:Ne -1]
- Map of estimates to be compressed : set to "valid" for each of the Ne estimates
- Validity flags for the estimates : Retrk_Range_Val_Flag [0:Ne -1]
- Processing parameters :
  - Type of compression : Type_Comp_Retrk_Range
  - Minimum number of estimates requested for the compression : Min_Pts_Retrk_Range
  - Minimum value of the standard deviation for outliers identification : Min_Std_Retrk_Range
  - Standard deviation scale factor for outliers identification : Scale_Retrk_Range
  - Center of the averaged measurement : Center_Av_Meas

ACCURACY

For the altimeter range, a linear regression is requested because of the high altitude rate (maximum value about 15 m/s). A parabolic regression is not recommended because the noise of the 20-Hz estimates is usually greater than the signal induced by the acceleration. The parabolic regression has been tested by JPL for TOPEX measurements, but it has not been retained because of the instability of the second order coefficient (acceleration).

---

(4) 2 states for each point of the map: "valid" or "invalid"

COMMENTS

None

REFERENCES

None

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31401 TOULOUSE CEDEX 4

ALT_COM_BAC_01 - To edit and compress the corrected AGC

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
Checked by:	For the JASON-1 SWT M. SROKOSZ E. RODRIGUEZ For the JASON-1 Project P. VINCENT CNES S. DESAI JPL	
Approved by:	P. VINCENT CNES	

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the corrected AGC (Ku and C bands) from elementary estimates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Tracker AGC validity flags (Ku and C bands)
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_BAC_01 - To correct the AGC":
    - Corrected Ku-band AGC (20 Hz)
    - Corrected C-band AGC (20 Hz)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement
  - Processing parameters, i.e. for each parameter:
    - Minimum value of the standard deviation for outliers identification
    - Minimum number of estimates requested for the compression
    - Standard deviation scale factor for outliers identification

Output data

- For each parameter (Ku and C bands corrected AGC):
  - Compressed value (1 Hz)
  - Standard deviation

- Updated quality information (map of valid estimates, number of valid estimates , validity of the compressed estimate)

Mathematical statement

The compression process is performed from the valid elementary estimates, which are identified from the input level 1.0 tracker AGC validity flags. It consists of an arithmetic averaging.

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the elementary residuals (estimate - model) with the value of the standard deviation of the elementary estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected elementary estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

For each averaged measurement, the editing and compression of the elementary estimates of the corrected AGCs (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Corrected AGCs parameters [Ku/C]:
  - Elementary estimates : AGC [0:Ne -1] (dB)
  - Validity flags [1] : Trk_AGC_Val_Flag [0:Ne -1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)
- Editing and compression parameters [Ku/C] [2]:
  - Minimum number of estimates requested for the compression : Min_Pts_AGC (/)
  - Minimum value of the standard deviation for outliers identification : Min_Std_AGC (dB)
  - Standard deviation scale factor for outliers identification : Scale_AGC (/)

Output data

- The following parameters for the corrected AGC [Ku/C]:
  - Compressed estimate : AGC_Mean (dB)

---

[1] 2 states: "valid" or "invalid"

[2] Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

- Standard deviation : AGC_Std (dB)
- Map of valid estimates [3] : AGC_Map [0:Ne-1] (/)
- Number of valid estimates : AGC_Nval (/)
- Validity of the compressed estimate [1] : AGC_Mean_Val_Flag (/)

• Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

• Number of estimates to be compressed : Ne
• Estimates : AGC [0:Ne -1]
• Map of estimates to be compressed : set to "valid" for each of the Ne estimates
• Validity flags for the estimates : Trk_AGC_Val_Flag [0:Ne -1]
• Processing parameters :
  - Type of compression : set to "arithmetic averaging"
  - Minimum number of estimates requested for the compression : Min_Pts_AGC
  - Minimum value of the standard deviation for outliers identification : Min_Std_AGC
  - Standard deviation scale factor for outliers identification : Scale_AGC
  - Center of the averaged measurement : not requested

ACCURACY

An arithmetic averaging is the most appropriate method, due to the low variation of the signal over one second.

COMMENTS

• Statistics relevant to the AGC are performed from elementary estimates expressed in dB. This operation is correct over ocean surfaces where the variation of the AGC is small enough within one source packet so as the logarithmic transfer function may be considered linear.

REFERENCES

None

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[3] 2 states for each point of the map: "valid" or "invalid"

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31401 TOULOUSE CEDEX 4

ALT_COM_BAC_02 - To edit and compress the corrections for instrumental errors on the AGC

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
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Approved by:	P. VINCENT CNES	

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the correction for instrumental errors on the AGC (Ku and C bands) from elementary estimates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data: None
- Computed data:
  - From "ALT_PHY_BAC_01 - To correct the AGC":
    - Correction for instrumental errors on the Ku-band AGC (20 Hz)
    - Correction for instrumental errors on the C-band AGC (20 Hz)
  - From "ALT_COM_BAC_01 - To edit and compress the corrected AGC":
    - Map of valid estimates for the Ku-band corrected AGC (1 Hz)
    - Map of valid estimates for the C-band corrected AGC (1 Hz)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary measurements per averaged measurement

Output data

- For each parameter (correction for instrumental errors on the Ku and C bands AGC):
  - Compressed value (1 Hz)
  - Standard deviation
  - Updated quality information

Mathematical statement

The compression process is performed from the elementary estimates used to compute the averaged value of the corrected AGC (see "ALT_COM_BAC_01 - To edit and compress the corrected AGC"). It consists of an arithmetic averaging.

ALGORITHM SPECIFICATION

For each averaged measurement, the compression of the elementary estimates of the correction of instrumental errors on the AGC (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Correction for instrumental errors on the AGC [Ku/C] : Cor_Instr_AGC [0:Ne -1] (dB)
- Map of valid estimates for the corrected AGC [Ku/C] (1) : AGC_Map [0:Ne-1] (/)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne (/)

Output data

- The following parameters for the correction of instrumental errors on the AGC [Ku/C]:
  - Compressed estimate : Cor_Instr_AGC_Mean (dB)
  - Standard deviation : Cor_Instr_AGC_Std (dB)
  - Map of valid estimates (1) : Cor_Instr_AGC_Map [0:Ne-1] (/)
  - Number of valid estimates : Cor_Instr_AGC_Nval (/)
  - Validity of the compressed estimate (2) : Cor_Instr_AGC_Mean_Val_Flag (/)
- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Ne
- Estimates : Cor_Instr_AGC [0:Ne -1]

(1) 2 states for each point of the map: "valid" or "invalid"

(2) 2 states: "valid" or "invalid"

- Map of estimates to be compressed : AGC_Map [0:Ne-1]
- Validity flags for the estimates : set to "valid"
- Processing parameters :
  - Type of compression : set to "arithmetic averaging"
  - Minimum number of estimates requested for the compression : set to "0"
  - Minimum value of the standard deviation for outliers identification : set to "+ ∞"
  - Standard deviation scale factor for outliers identification : set to "0"
  - Center of the averaged measurement : not requested

ACCURACY

An arithmetic averaging is the most appropriate method, due to the low variation of the signal over one second.

COMMENTS

- Statistics relative to the AGC corrections are performed from elementary estimates expressed in dB. This operation is correct over ocean surfaces where the variation of the AGC is small enough within one source packet so as the logarithmic transfer function may be considered linear.

REFERENCES

None

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ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived)

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
Checked by:	For the JASON-1 SWT M. SROKOSZ E. RODRIGUEZ For the JASON-1 Project P. VINCENT CNES S. DESAI JPL	
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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute a 1-Hz compressed estimate of the square of the off-nadir angle derived from a **N-seconds** set of 1-Hz on-board waveform-derived estimates (N ≥ 1).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tag (1 Hz)
- Computed data:
  - From "GEN_ENV_SUR_01 - To determine the surface type":
    - Surface type (1 Hz) (1)
  - From "ALT_PHY_MIS_01 - To compute the square of the off-nadir angle from the on-board waveform-derived estimates":
    - Square of the off-nadir angle (1 Hz)
    - Validity flag for the square of the off-nadir angle (1 Hz)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Processing parameters for the selection of the data to be compressed (see RD11)
  - Processing parameters for data averaging:
    - Minimum value of the standard deviation for outliers identification
    - Minimum number of estimates requested for the compression
    - Standard deviation scale factor for outliers identification

---

(1) 4 states: “open ocean or semi-enclosed seas”, “enclosed seas or lakes”, “continental ice” or “land”

Title: ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived)

Definition, Accuracy and Specification

Output data

- For the square of the off-nadir angle:
  - Compressed value (1 Hz)
  - Standard deviation
  - Updated quality information

Mathematical statement

The 1-Hz compressed estimate of the square of the off-nadir angle is computed over a N≥1-second window centered on the processed 1-Hz measurement, by arithmetic averaging of the corresponding 1-Hz estimates.

The compression process is performed from the valid ocean 1-Hz estimates, which are identified from the input flags (surface type and validity flag for the square of the off-nadir angle).

Outliers are detected and rejected within this process. The outliers detection is based on the comparison of the 1-Hz residuals (estimate - model) with the value of the standard deviation of the 1-Hz estimates scaled by a constant. To account for some special cases (low noise level), this detection is performed only if the standard deviation exceeds a predefined threshold. The compressed estimate will be valid only if the final number of selected estimates exceeds the minimum requested value. The updated corresponding quality information (number of valid estimates, maps of valid points, validity of the compressed estimate) are provided on output.

ALGORITHM SPECIFICATION

Warning: The data selection for the editing and compression of the square of the off-nadir angle is considered as a "data management" algorithm (see section 1). It is specified in RD11. For each averaged measurement, this algorithm will provide:

- the selected 1-Hz estimates and the corresponding validity flags (selected from the time-tag of the processed measurement and the width of the averaging window)
- a map of the estimates to be compressed (measurements performed over "open ocean or semi-enclosed seas" or over "enclosed seas or lakes")
- the number of 1-Hz estimates to be averaged.

For each averaged measurement, the editing and compression of the 1-Hz estimates of the square of the off-nadir angles is specified hereafter.

Input data

- Square of the off-nadir angle parameters:
  - 1-Hz estimates : Off_Nad_Wf2 [0:Nav -1] (degree^2)

- Map of estimates to be compressed [(1)] : Off_Nad_Wf2_Map_Comp [0:Nav -1] (/)
- Validity flags [(2)] : Off_Nad_Wf2_Val_Flag [0:Nav -1] (/)

- Number of 1-Hz estimates to be averaged : Nav (/)
- Editing and compression parameters:
  - Minimum number of estimates requested for the compression : Min_Pts_Off_Nad_Wf2 (/)
  - Minimum value of the standard deviation for outliers identification : Min_Std_Off_Nad_Wf2 ($degree^2$)
  - Standard deviation scale factor for outliers identification : Scale_Off_Nad_Wf2 (/)

Output data

- The following parameters for the square of the off-nadir angle:
  - Compressed estimate : Off_Nad_Wf2_Mean ($degree^2$)
  - Standard deviation : Off_Nad_Wf2_Std ($degree^2$)
  - Number of valid estimates : Off_Nad_Wf2_Nval (/)
  - Validity of the compressed estimate [(2)] : Off_Nad_Wf2_Mean_Val_Flag (/)
- Execution status

Processing

The above-mentioned parameters are computed using mechanism "GEN_MEC_COM_04 - Editing and compression" (AD11), with the following inputs:

- Number of estimates to be compressed : Nav
- Estimates : Off_Nad_Wf2 [0:Nav -1]
- Map of estimates to be compressed : Off_Nad_Wf2_Map_Comp [0:Nav -1]
- Validity flags for the estimates : Off_Nad_Wf2_Val_Flag [0:Nav -1]
- Processing parameters :
  - Type of compression : set to "arithmetic averaging"
  - Minimum number of estimates requested for the compression : Min_Pts_Off_Nad_Wf2
  - Minimum value of the standard deviation for outliers identification : Min_Std_Off_Nad_Wf2
  - Standard deviation scale factor for outliers identification : Scale_Off_Nad_Wf2
  - Center of the averaged measurement : not requested

---

(1) 2 states for each point of the map: "valid" or "invalid"

(2) 2 states: "valid" or "invalid"

ACCURACY

TBD

COMMENTS

None

REFERENCES

None

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ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
Checked by:	For the JASON-1 SWT M. SROKOSZ E. RODRIGUEZ For the JASON-1 Project P. VINCENT CNES S. DESAI JPL	
Approved by:	P. VINCENT CNES	

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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the 20-Hz so-called "scaling factors for Sigma0 evaluation" (requested to determine the backscatter coefficients from the on-ground retracked amplitudes), and to compute the 1-Hz so-called "scaling factor for on-board retracked Sigma0 evaluation" (requested to determine the backscatter coefficients from the on-board estimates of the AGC combined with the retracked amplitude of the waveforms), for the Ku and C bands. These parameters account for the total power of the altimeter PTR (POSEIDON-2 LTM calibration parameters). Moreover, the 1-Hz Ku and C bands internal calibration correction on the backscatter coefficients are computed (to be stored in the SGDR product).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tag (1 Hz)
  - Orbit altitude (1 Hz)
  - Tracker AGC validity flags
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_BAC_01 - To correct the AGC":
    - Ku-band corrected AGC (20 Hz)
    - C-band corrected AGC (20 Hz)
- Dynamic auxiliary data:
  - Time-stamped POSEIDON-2 LTM calibration parameters (PTR) , i.e. for each band (Ku, C):
    - Total power of the PTR
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Number of elementary estimates per averaged measurement
    - Antenna gain (Ku and C bands)

  * Altimeter wavelength (Ku and C bands)
  * FFT step in tracking mode, expressed in time and in frequency (Ku and C bands)(1)
  * Ratio of the losses between the transmission/reception and the calibration paths (Ku and C bands)
  * Number of pulses per waveform (1)
  * Parameters used to perform the on-board PTR calibrations (Ku and C bands) (1):
    ◊ AGC used to calibrate the PTR
    ◊ Number of pulses used to calibrate the PTR
    ◊ FFT step in PTR calibration mode (expressed in frequency)
  * Pre-launch calibration parameters (Ku and C bands) (1):
    ◊ Total power of the PTR
    ◊ AGC used to calibrate the PTR
    ◊ Number of pulses used to calibrate the PTR
    ◊ FFT step in PTR calibration mode (expressed in frequency)
- Universal constants:
  * Light velocity
  * Earth radius

Output data

- Ku-band scaling factors for Sigma0 evaluation (20 Hz)
- C-band scaling factors for Sigma0 evaluation (20 Hz)
- Ku-band scaling factor for on-board retracked Sigma0 evaluation (1 Hz)
- C-band scaling factor for on-board retracked Sigma0 evaluation (1 Hz)
- Ku-band internal calibration correction on the backscatter coefficient (1 Hz)
- C-band internal calibration correction on the backscatter coefficient (1 Hz)

Mathematical statement

Principle

- The radar equation applied to the altimeter may be expressed by (Ref. 1):

$$P_r = \frac{P_t . G_{ant}^2 . \lambda^2 . c . \Delta t . R_e}{64 . \pi^2 . H^3 . (R_e + H) . L_{at}} . \sigma_0 \qquad (1)$$

where:

(1) depends on the altimeter configuration

- P_r = received power at the antenna flange
- P_t = transmitted power at the antenna flange
- G_{ant} = antenna gain (power)
- λ = wavelength
- c = light velocity
- Δt = FFT step in time
- R_e = earth radius
- σ_0 = backscatter coefficient
- H = altitude (orbit)
- L_{at} = losses due to the propagation in the atmosphere

- The transmitted power is given by:

$$P_t = \frac{P_{SSPA}}{L_t} \tag{2}$$

where:

- P_{SSPA} = peak power transmitted by the SSPA
- L_t = losses between the SSPA and the antenna flange

- The waveform amplitude P_u provided by the (on-board) retracking algorithm may be expressed as a function of the received power at the antenna flange (P_r), by:

$$P_u = \frac{P_r}{L_r}.G_r.\sum_j PTR_j \tag{3}$$

where:

- L_r = losses between the antenna flange and the low noise amplifier (LNA)
- G_r = gain of the receiver chain in radar mode between the LNA and the FFT output
- PTR_j = PTR samples (with a frequency step Δf_t of the FFT in tracking mode)

- Combining the three previous equations, and ignoring the losses due to the propagation in the atmosphere (which will be accounted for in the level 2 processing), the waveform amplitude provided by the (on-board) retracking algorithm is:

$$P_u = \frac{G_{ant}^2.\lambda^2.c.\Delta t.R_e}{64.\pi^2.H^3.(R_e + H)} \cdot \frac{P_{SSPA}}{L_t} \cdot \frac{G_r}{L_r} \sum_j PTR_j.\sigma_0 \tag{4}$$

- In this equation, some parameters as the peak power transmitted by the SSPA and the PTR, are unknown at the time of the measurement. Assuming a slow variation of these parameters versus time, the use of internal calibration measurements will allow the computation of the backscatter coefficient. Indeed, the total power P_{PTR} of the PTR (LTM calibration parameter derived from the internal calibration process) may be expressed as:

$$P_{PTR} = \frac{P_{SSPA}}{L_c}.G_c.\sum_k PTR_k \qquad (5)$$

where:

- L_c = losses between the SSPA and the LNA
- G_c = gain of the receiver chain in calibration mode between the LNA and the FFT output
- PTR_k = PTR samples (with a frequency step Δf_c of the FFT in calibration mode)

- Accounting for the relationship between the PTR samples and the FFT steps in tracking and in calibration modes:

$$\Delta f_t.\sum_j PTR_j = \Delta f_c.\sum_k PTR_k \qquad (6)$$

and accounting for the expression of the gains ratio:

$$\frac{G_c}{G_r} = \frac{N_c}{N_t}.\frac{10^{-\frac{AGC_c}{10}}}{10^{-\frac{AGC_t}{10}}} \qquad (7)$$

where:

- N_c = number of pulses used in calibration
- N_t = number of pulses used in tracking
- AGC_c = AGC used in calibration
- AGC_t = AGC used in tracking,

the backscatter coefficient is given by:

$$\sigma_0 = \left(\frac{64.\pi^2.H^3.(R_e + H)}{G_{ant}^2.\lambda^2.c.\Delta t.R_e}.\frac{L_t.L_r}{L_c}.\frac{\Delta f_t}{\Delta f_c}.\frac{N_c}{N_t}.\frac{1}{10^{\frac{AGC_c}{10}}.P_{PTR}}\right)\left(10^{\frac{AGC_t}{10}}.P_u\right) \qquad (8)$$

The losses (L_t, L_r, L_c) and/or their ratio ($R_{loss} = L_t.L_r/L_c$) are assumed to be constant and characterized before launch.

- The internal calibration correction on the backscatter coefficients may be expressed with respect to a prelaunch calibration, which is characterized by the following input parameters:
  - Total power of the PTR : $P_{PTR,prelaunch}$
  - AGC used to calibrate the PTR : $AGC_{c,prelaunch}$
  - Number of pulses used to calibrate the PTR : $N_{c,prelaunch}$
  - FFT step in PTR calibration mode (expressed in frequency) : $\Delta f_{c,prelaunch}$

Indeed, computing the corrected backscatter coefficient (σ_{0cor}) according to (8) and computing the raw backscatter coefficient (σ_{0raw}) according to (8) where N_c, Δf_c, AGC_c and P_{PTR} are superseded by the corresponding prelaunch parameters, the internal calibration correction ($\Delta\sigma_{0cal}$) may be derived by:

$$\Delta\sigma_{0\,cal} = \frac{\sigma_{0\,cor}}{\sigma_{0\,raw}} = \frac{\Delta f_{c,prelaunch}}{\Delta f_c} \cdot \frac{N_c}{N_{c,prelaunch}} \cdot \frac{P_{PTR,prelaunch}}{P_{PTR}} .10^{\frac{AGC_{c,prelaunch} - AGC_c}{10}} \qquad (9)$$

Computation of the 20-Hz scaling factors for the level 2 Sigma0 evaluation and of the 1-Hz scaling factors for the on-board retracked Sigma0 evaluation (Ku and C bands)

The computations steps (for each band) are the following:

- Selection of the total power of the PTR (P_{PTR}) to be used (calibration point just before the measurement)
- Computation of the 1-Hz scaling factors for the on-board retracked Sigma0 evaluation (Ku and C bands):

  These scaling factors are computed according to (8), expressed in dB, where AGC_t is set to 0 (dB), and where the waveform amplitude P_u is set to 1 (i.e. 0 dB).

  They represent thus the backscatter coefficient for the 1-Hz measurement from which the combined AGC and on-board retracked amplitude is removed. (The 1-Hz on-board retracked backscatter coefficients will be obtained by adding the 1-Hz combined AGC and on-board retracked amplitude, expressed in dB, to these scaling factors: see "ALT_PHY_BAC_03 - To compute the on-board retracked backscatter coefficients").
- Computation of the 20-Hz scaling factors for the level 2 Sigma0 evaluation (Ku and C bands):

  These scaling factors are computed according to (8), expressed in dB, where AGC_t is superseded by the corresponding input corrected AGC, and where the waveform amplitude P_u is set to 1 (i.e. to 0 dB).

  They represent thus the backscatter coefficient for the 20-Hz measurements for a waveform amplitude equal to 1 (FFT power unit).

  These computations are performed only if the AGC is valid (using the input tracker AGC validity flags).
- Computation of the 1-Hz internal calibration corrections on the backscatter coefficient (Ku and C bands):

  These corrections are computed according to (9), expressed in dB.

ALGORITHM SPECIFICATION

Warning: The selection of the LTM calibration parameters to be used for each averaged measurement is considered as "data management" algorithm (see section 1). They are specified in RD11.

For each averaged measurement, the computation of the 1-Hz scaling factors for the on-board retracked backscatter coefficients (Ku or C bands), of the 20-Hz scaling factors for the level 2 Sigma0 evaluation (Ku or C bands) and of the 1-Hz internal calibration on the backscatter coefficients (Ku or C bands) are specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Orbit altitude : Orbit_Alt (m)

- Tracker AGC and validity flags [Ku/C]:
  - Corrected AGC : AGC [0:Ne-1] (dB)
  - Tracker AGC validity flag : Trk_AGC_Val_Flag [0:Ne-1] (/)
- PTR calibration parameters (selected) [Ku/C]:
  - Total power of the PTR : PTR_Pow (FFT power unit)
- POSEIDON-2 instrumental characterization data:
  - Number of elementary estimates per averaged measurement : Ne
  - Antenna gain [Ku/C] : Ant_Gain (dB)
  - Emitted frequency [Ku/C] : Freq (Hz)
  - FFT step in tracking mode (time) (1) : FFT_Trk_T (s)
  - FFT step in tracking mode (frequency) : FFT_Trk_F (Hz)
  - Ratio of the losses between Trans/Recep and Cal paths [Ku/C] : Ratio_TRC (dB)
  - Number of [Ku/C] pulses per waveform (2) : Np_Trk (/)
  - Parameters used to perform the on-board PTR calibration (3):
    - Automatic Gain Control:
      - First AGC (AGC1) : AGC1_PTR (dB)
      - Second AGC (AGC2) : AGC2_PTR (dB)
    - Number of pulses : Np_PTR (/)
    - FFT step (frequency) : FFT_PTR_F (Hz)
  - Prelaunch PTR calibration parameters (3):
    - Total power of the PTR : PTR_Pow_PL (FFT power unit)
    - Automatic Gain Control:
      - First AGC (AGC1) : AGC1_PTR_PL (dB)
      - Second AGC (AGC2) : AGC2_PTR_PL (dB)
    - Number of pulses : Np_PTR_PL (/)
    - FFT step (frequency) : FFT_PTR_F_PL (Hz)
- Universal constants:
  - Light velocity : Light_Vel (m/s)
  - Earth radius : Earth_Rad (m)

(1) Value to be selected according to the emitted bandwidth (altimeter configuration data)

(2) Value to be selected according to the Ku/C band sequencing (altimeter configuration data)

(3) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

Output data

- Scaling factors for Sigma0 evaluation (20 Hz) [Ku/C] : Scale_Sigma0 [0:Ne-1] (dB)
- Scaling factor for on-board retracked Sigma0 evaluation (1 Hz) [Ku/C] : Scale_OB_Sigma0(dB)
- Internal calibration correction on the backscatter coefficient (1 Hz) [Ku/C] : Cor_Cal_Sigma0 (dB)
- Execution status

Processing

- The global AGCs used to perform the on-board PTR calibration and the prelaunch PTR calibration are built by:

$$AGC\_PTR = AGC1\_PTR + AGC2\_PTR \quad (4)$$

$$AGC\_PTR\_PL = AGC1\_PTR\_PL + AGC2\_PTR\_PL \quad (5)$$

- The 1-Hz scaling factor for on-board retracked Sigma0 evaluation is computed by:

$$\begin{aligned} Scale\_OB\_Sigma0 = {} & 10 * \log_{10}(64) + 20 * \log_{10}(\pi) + 30 * \log_{10}(Orbit\_Alt) + 10 * \log_{10}(Earth\_Rad + Orbit\_Alt) \\ & - 2 * Ant\_Gan + 20 * \log_{10}(Freq) - 30 * \log_{10}(Light\_Vel) - 10 * \log_{10}(FFT\_Trk\_T) \\ & - 10 * \log_{10}(Earth\_Rad) + Ratio\_TRC + 10 * \log_{10}(FFT\_Trk\_F) - 10 * \log_{10}(FFT\_PTR\_F) \\ & + 10 * \log_{10}(Np\_PTR) - 10 * \log_{10}(Np\_Trk) - AGC\_PTR - 10 * \log_{10}(PTR\_Pow) \end{aligned} \quad (1)$$

- For each elementary measurement j ∈ [0, Ne-1], the 20-Hz scaling factor for Sigma0 evaluation is computed as follows:
  - If the tracker AGC validity flag (Trk_AGC_Val_Flag(j)) is set to "valid", then:

$$Scale\_Sigma0(j) = Scale\_OB\_Sigma0 + AGC(j) \quad (2)$$

  - Else (Trk_AGC_Val_Flag(j) set to "invalid"), then Scale_Sigma0(j) is set to a default value.
- The 1-Hz Internal calibration correction on the backscatter coefficient is computed by:

$$\begin{aligned} Cor\_Cal\_Sigma0 = {} & [10 * \log_{10}(Np\_PTR) - 10 * \log_{10}(Np\_PTR\_PL)] \\ & - [10 * \log_{10}(FFT\_PTR\_F) - 10 * \log_{10}(FFT\_PTR\_F\_PL)] \\ & - [AGC\_PTR - AGC\_PTR\_PL] \\ & - [10 * \log_{10}(PTR\_Pow) - 10 * \log_{10}(PTR\_Pow\_PL)] \end{aligned} \quad (3)$$

ACCURACY

Regarding the instrumental losses (between the SSPA and the antenna flange, between the antenna flange and the LNA, and between the SSPA and the LNA), the possible variation of their ratio (involved in the expression of the backscatter coefficient) during the mission is negligible (TBC).

Losses due to the propagation in the atmosphere are ignored in the computation of the backscatter coefficient. They will be accounted for in the level 2 processing (see RD4).

(TBC) The impact on the backscatter coefficient estimation of the temperature of the altimeter components is negligible. In the POSEIDON-1 on-ground processing, the total power of the PTR had to be interpolated versus the SSPA temperature, because the altimeter was frequently switched on and off.

COMMENTS

None

REFERENCES

- **Ref. 1:** Calibration interne de l'altimètre POSEIDON - Principe, résultats et précision
  CNES 86/300 - CT/DRJ/TIT/RL-HY, 06/12/86

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ALT_PHY_BAC_03 - To compute the on-board retracked backscatter coefficients

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To compute the Ku-band and C-band on-board retracked backscatter coefficients (from the 1-Hz scaling factors for Sigma0 evaluation and from the on-board estimates of the AGC combined with the retracked amplitude of the waveforms).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Ku band combined AGC and on-board retracked amplitude (1 Hz) and associated validity flag
  - C band combined AGC and on-board retracked amplitude (1 Hz) and associated validity flag
- Computed data:
  - From "ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation":
    - Ku-band scaling factor for on-board retracked Sigma0 evaluation (1 Hz)
    - C-band scaling factor for on-board retracked Sigma0 evaluation (1 Hz)
- Dynamic auxiliary data: None
- Static auxiliary data: None

Output data

- Ku-band on-board retracked backscatter coefficient (1 Hz) and associated validity flag
- C-band on-board retracked backscatter coefficient (1 Hz) and associated validity flag

Mathematical statement

See "ALT_PHY_BAC_02 - To compute the scaling factors for Sigma0 evaluation".

ALGORITHM SPECIFICATION

For each averaged measurement, the computation of the on-board retracked backscatter coefficient and of the corresponding validity flag (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Scaling factor for on-board retracked Sigma0 evaluation [Ku/C] : Scale_OB_Sigma0 (dB)
- Combined AGC and on-board retracked amplitude, and validity flag [Ku/C]:
  - Combined AGC and on-board retracked amplitude : Comb_AGC_Ampl (dB)
  - Validity flag for the combined AGC and on-board retracked amplitude [1] : Comb_AGC_Ampl_Val_Flag (/)

Output data

- On-board retracked backscatter coefficient [Ku/C] : Retrk_Sigma0 (dB)
- On-board retracked backscatter coefficient validity flag [Ku/C] [1] : Retrk_Sigma0_Val_Flag (/)
- Execution status

Processing

The on-board retracked backscatter coefficient and the associated validity flag are computed using mechanism "GEN_MEC_COR_01 - Computation of a tracking/retracking combined parameter" (AD11), with the following inputs:

- Tracking-derived parameter : Scale_OB_Sigma0
- Tracking-derived parameter validity flag : set to "valid"
- Retracking-derived parameter : Comb_AGC_Ampl
- Retracking-derived parameter validity flag : Comb_AGC_Ampl_Val_Flag
- Type of conversion for the retracking-derived parameter : set to "none"
- Light velocity : not requested

ACCURACY

N/A

[1] 2 states: "valid" and "invalid"

COMMENTS

None

REFERENCES

None

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ALT_PHY_SNR_01 - To compute the SNR from the on-board estimates

DEFINITION, ACCURACY AND SPECIFICATION

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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the signal to noise ratio (Ku and C bands) from the 1-Hz on-board estimate of the "AGC combined with the retracked amplitude", the 1-Hz corrected AGC and the 1-Hz thermal noise level estimate.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Ku band combined AGC and on-board retracked amplitude (1 Hz): $P_{comb\text{-}Ku}$
  - C band combined AGC and on-board retracked amplitude (1 Hz): $P_{comb\text{-}C}$
  - Combined AGC and amplitude validity flags
  - Ku-band thermal noise level (1 Hz): $P_{TN\text{-}Ku}$
  - C-band thermal noise level (1 Hz): $P_{TN\text{-}C}$
  - Thermal noise validity flags
  - Altimeter configuration data
- Computed data:
  - From "ALT_COM_BAC_01 - To edit and compress the corrected AGC":
    - Ku-band corrected AGC (1 Hz): $AGC_{c\text{-}Ku}$
    - C-band corrected AGC (1 Hz): $AGC_{c\text{-}C}$
    - Corrected AGC validity flags (1 Hz)
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Processing parameters:
    - Minimum value of AGC requested to set SNR to AGC in case of null thermal noise (Ku and C bands): $AGC_{threshKu}$ and $AGC_{threshC}$
    - Bias between SNR and AGC (Ku and C bands): $Bias_{Ku}$ and $Bias_C$

Output data

- Ku-band signal to noise ratio (1 Hz)
- C-band signal to noise ratio (1 Hz)
- Validity flag for the signal to noise ratio (Ku and C bands)

Mathematical statement

For each band, the 1-Hz on-board retracked amplitude P_u (dB) is restored from the input data, by:

$$P_u = P_{comb} - AGC_c \quad (1)$$

The signal to noise ratio is then derived by:

$$SNR = P_u - 10.\log_{10}(P_{TN}) \quad (2)$$

where P_{TN} is the input 1-Hz thermal noise level (amplitude).

The input validity flags are managed. Moreover, if the thermal noise level is set to 0 (see section "accuracy"), the signal to noise ratio is set to AGC_c + Bias if AGC_c exceeds a threshold (AGC_{thresh}), or to P_u otherwise (i.e. that P_{TN} is assumed to be equal to the amplitude resolution of the analysis window).

ALGORITHM SPECIFICATION

For each averaged measurement, the computation of the Ku band or C band signal to noise ratio is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Combined AGC/amplitude and validity flag [Ku/C]:
  - Combined AGC and on-board retracked amplitude : OB_AGC_Amp (dB)
  - Combined AGC and amplitude validity flag [(1)] : OB_AGC_Amp_Val_Flag (/)
- Thermal noise level and validity flag [Ku/C]:
  - Thermal noise level : Noise (FFT power unit)
  - Thermal noise level validity flag : Noise_Val_Flag (/)
- Corrected AGC and validity flag (1 Hz) [Ku/C]:
  - Corrected AGC : AGC_Mean (dB)

[(1)] 2 states: "valid" or "invalid"

- Corrected AGC validity flag : AGC_Mean_Val_Flag (/)

- Processing parameters relative to the SNR derived from on-board estimates [Ku/C] [(1)]:
  - Minimum value of AGC requested to set SNR to AGC in case of null thermal noise : AGC_Thresh (dB)
  - Bias between SNR and AGC : SNR_AGC_Bias (dB)

Output data

- Signal to noise ratio [Ku/C] : SNR (dB)
- Validity flag for the signal to noise ratio [Ku/C] : SNR_Val_Flag (/)
- Execution status

Processing

- If the three following flags:
  - Combined AGC and amplitude validity flag (OB_AGC_Amp_Val_Flag)
  - Corrected AGC validity flag (AGC_Mean_Val_Flag)
  - Thermal noise level validity flag (Noise_Val_Flag)

  are set to "valid", then:
  - SNR is computed as follows:
    - ∗ The amplitude of the waveform is restored by:

      $$Amp = OB\_AGC\_Amp - AGC\_Mean \tag{1}$$

    - ∗ If Noise > 0, then:

      $$SNR = Amp - 10 * \log_{10}(Noise) \tag{2}$$

      Else:
      - ◊ If AGC_Mean > AGC_Thresh, then:

        $$SNR = AGC\_Mean + SNR\_AGC\_Bias \tag{3}$$

      - ◊ Else:

        $$SNR = Amp \tag{4}$$

  - The validity flag for the signal to noise ratio (SNR_Val_Flag) is set to "valid".
- Else (at least one of the three flags is set to "invalid"), then:
  - SNR is set to a default value
  - SNR_Val_Flag is set to "invalid"

---

(1) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

ACCURACY

The signal to noise ratio is requested in the level 1b processing to access the modeled instrumental corrections tables. Its value is derived from the on-board estimates of amplitudes of the waveform (the thermal noise level P_{TN} is derived from an averaging of samples of the first plateau, while the amplitude P_u is derived from a fit of the waveform with a mean return power model). This parameter is thus fully consistent with the one used in the simulator to build the corrections tables.

Due to the quantization of the waveforms, the estimation of the thermal noise level could be inaccurate in the case of a high signal to noise ratio. Indeed, assuming a reference amplitude level in the analysis window P_{ref} equal to 160 (RD8) with a quantization step of 1, which corresponds to the maximum value of an averaging of 8 consecutive samples, and which is thus close to P_u+P_{TN}, the thermal noise level will be about:

$$P_{TN} = \frac{P_{ref}}{1+10^{\frac{SNR}{10}}}$$

In case of a signal to noise ratio of 13 dB, which is the nominal expected value (see RD6), the thermal noise level will be about 7.5 FFT units, and the error on its estimate will thus be small. However, the thermal noise level will become smaller than the quantization step and thus set to 0 if the signal to noise ratio will be greater than 22 dB.

COMMENTS

None

REFERENCES

None

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ALT_COR_GEN_01 - To compute the mispointing corrections

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz corrections of the impact of an antenna mispointing on the Ku and C bands altimetric estimates (altimeter range, significant waveheight and backscatter coefficient) from models depending on the significant waveheight and the square of the off-nadir angle (interpolated platform data or possibly waveforms-derived data).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
  - Significant waveheight (1 Hz): SWH
  - Significant waveheight validity flag
- Computed data (see "comments"):
  - From "PLA_PHY_MIS_01 - To compute the platform-derived off-nadir angle" - for Level 1b production (see comments), or from "ALT_COM_MIS_01 - To edit and compress the square of the off-nadir angle (on-board waveform-derived)" - for OSDR production (see comments):
    - Square of the off-nadir angle: ξ^2
    - Validity flag for the square of the off-nadir angle
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Processing parameters:
    - Coefficients for the Ku-band altimeter range correction: $\{c_{h\text{-}Ku,i}\}_{i\ =\ 0,\ 4}$
    - Coefficients for the C-band altimeter range correction: $\{c_{h\text{-}C,i}\}_{i\ =\ 0,\ 4}$
    - Coefficients for the significant waveheight correction: $\{c_{SWH,i}\}_{i\ =\ 0,\ 4}$
    - Coefficients for Ku-band backscatter coefficient correction: $\{c_{Sig0\text{-}Ku,i}\}_{i\ =\ 0,\ 4}$
    - Coefficients for the C-band backscatter coefficient correction: $\{c_{Sig0\text{-}C,i}\}_{i\ =\ 0,\ 4}$
    - Validity thresholds for the corrected significant waveheight

* Threshold from which the square of the off-nadir angle is set to 0

Output data

- Ku-band mispointing correction on the altimeter range (1 Hz)
- C-band mispointing correction on the altimeter range (1 Hz)
- Mispointing correction on the significant waveheight (1 Hz)
- Corrected significant waveheight: SWH_c (1 Hz)
- Validity flag for the corrected significant waveheight (1 Hz)
- Ku-band mispointing correction on the backscatter coefficient (1 Hz)
- C-band mispointing correction on the backscatter coefficient (1 Hz)

Mathematical statement

Principle

The mispointing corrections on an estimate x (altimeter range, significant waveheight or backscatter coefficient) may be modeled by (Ref. 1):

$$\Delta_x = c_{x,0} + \left[c_{x,1}.SWH_c + c_{x,2}\right]\xi^2 + \left[c_{x,3}.SWH_c + c_{x,4}\right]\xi^4 \qquad (1)$$

where:

- SWH_c represents the corrected significant waveheight
- $\{c_{x,i}\}_{i=0,4}$ is a set of coefficients for parameter x

Computation of the corrected significant waveheight and of the mispointing corrections

- The corrected significant waveheight ($SWH_c = SWH + \Delta_{SWH}$) is determined from (1), by:

$$SWH_c = \frac{SWH + c_{SWH,0} + c_{SWH,2}.\xi^2 + c_{SWH,4}.\xi^4}{1 - c_{SWH,1}.\xi^2 - c_{SWH,3}.\xi^4} \qquad (2)$$

  A validity flag for the corrected significant waveheight is built from the corresponding input validity flags (relative to the significant waveheight and to the square of the off-nadir angle), and from the results of the comparison of the corrected significant waveheight to a predefined interval.

  The computation of the corrected significant waveheight and of the mispointing corrections is performed only if the significant waveheight and the square of the off-nadir angle are valid and if the square of the off-nadir angle is greater than a threshold (negative value close to 0). This threshold corresponds to the maximum error allowed on the estimation of a null mispointing, accounting for the noise which affects the estimation. A negative estimate of the square of the off-nadir angle will then be set to 0 in the computations.

- The mispointing errors on the Ku and C bands altimeter range, on the Ku and C bands backscatter coefficients and on the significant waveheight are then computed according to (1) from the corresponding coefficients and from SWH_c. The corrections are set to 0 (and SWH_c is set to SWH) if the corrected significant waveheight is not valid.

ALGORITHM SPECIFICATION

For each averaged measurement, the computation of the corrections of the impact of an antenna mispointing on the altimeter range (Ku and C bands), the significant waveheight and the backscatter coefficient (Ku and C bands) are specified hereafter.

Input data

- Significant waveheight and validity flag:
  - Significant waveheight : SWH_Ku (m)
  - Significant waveheight validity flag : SWH_Ku_Val_Flag (/)
- Square of the off-nadir angle and validity flag:
  - Square of the off-nadir angle : Off_Nad2_Mean (degree^2)
  - Validity flag for the square of the off-nadir angle : Off_Nad2_Mean_Val_Flag (/)
- Processing parameters relative to the mispointing corrections (3):
  - Coefficients for the Ku-band altimeter range correction (1) : C_Range_Ku [0:4]
  - Coefficients for the C-band altimeter range correction (1) : C_Range_C [0:4]
  - Coefficients for the significant waveheight correction (1) : C_SWH_Ku [0:4]
  - Coefficients for the Ku-band backscatter coefficient correction (2) : C_Sigma0_Ku [0:4]
  - Coefficients for the C-band backscatter coefficient correction (2) : C_Sigma0_C [0:4]
  - Validity thresholds for the corrected significant waveheight:
    - Minimum valid estimate of the corrected significant waveheight : Min_Val_SWH (m)
    - Maximum valid estimate of the corrected significant waveheight : Max_Val_SWH (m)
  - Threshold from which the square of the off-nadir angle is set to 0 : Thresh_Off_Nad2 (degree^2)

Output data

- Ku-band mispointing correction on the altimeter range : Cor_Mis_Range_Ku (m)
- C-band mispointing correction on the altimeter range : Cor_Mis_Range_C (m)
- Mispointing correction on the significant waveheight : Cor_Mis_SWH_Ku (m)
- Corrected significant waveheight : SWH_Cor_Ku (m)
- Validity flag for the corrected significant waveheight : SWH_Cor_Ku_Val_Flag (/)
- Ku-band mispointing correction on the backscatter coefficient : Cor_Mis_Sigma0_Ku (dB)
- C-band mispointing correction on the backscatter coefficient : Cor_Mis_Sigma0_C (dB)

---

(3) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

(1) Units for coefficients order 0 to 4: m, degree^{-2}, m.degree^{-2}, degree^{-4}, m.degree^{-4}

(2) Units for coefficients order 0 to 4: dB, degree^{-2}, dB.degree^{-2}, degree^{-4}, dB.degree^{-4}

- Execution status

Processing

- If the validity flags for the significant waveheight (SWH_Ku_Val_Flag) and for the square of the off-nadir angle (Off_Nad2_Mean_Val_Flag) are set to "valid", and if Off_Nad2_Mean ≥Thresh_Off_Nad2, then:
  - The corrected significant waveheight is computed by: (1)

$$SWH\_Cor\_Ku = \frac{\begin{array}{c} SWH\_Ku + C\_SWH\_Ku(0) + C\_SWH\_Ku(2) * Off\_Nad2\_Mean \\ + C\_SWH\_Ku(4) * Off\_Nad2\_Mean^2 \end{array}}{1 - C\_SWH\_Ku(1) * Off\_Nad2\_Mean - C\_SWH\_Ku(3) * Off\_Nad2\_Mean^2}$$

    where Off_Nad2_Mean is set to 0 if it is smaller or equal to 0.
  - The validity flag for the corrected significant waveheight (SWH_Cor_Ku_Val_Flag) is built using mechanism "GEN_MEC_QUA_01 - Quality check from thresholds" (AD11) with the following inputs:
    - Parameter to be checked : SWH_Cor_Ku
    - Lower bound : Min_Val_SWH
    - Upper bound : Max_Val_SWH
  - If the validity flag for the corrected significant waveheight (SWH_Cor_Ku_Val_Flag) is set to "valid", then the mispointing corrections are computed according to the following expression:

$$\begin{aligned} Cor = {} & C(0) \\ & + [C(1) * SWH\_Cor\_Ku + C(2)] * Off\_Nad2\_Mean \\ & + [C(3) * SWH\_Cor\_Ku + C(4)] * Off\_Nad2\_Mean^2 \end{aligned} \qquad (2)$$

    where Off_Nad2_Mean is set to 0 if it is smaller or equal to 0, and where:
    - For the Ku-band altimeter range correction:
      - ◊ Cor represents Cor_Mis_Range_Ku
      - ◊ C(j) represents C_Range_Ku(j)
    - For the C-band altimeter range correction:
      - ◊ Cor represents Cor_Mis_Range_C
      - ◊ C(j) represents C_Range_C(j)
    - For the significant waveheight correction:
      - ◊ Cor represents Cor_Mis_SWH_Ku
      - ◊ C(j) represents C_SWH_Ku(j)

        - For the Ku-band backscatter coefficient correction:
            - Cor represents Cor_Mis_Sigma0_Ku
            - C(j) represents C_Sigma0_Ku(j)
        - For the C-band backscatter coefficient correction:
            - Cor represents Cor_Mis_Sigma0_C
            - C(j) represents C_Sigma0_C(j)
    - Else (SWH_Cor_Ku_Val_Flag set to "invalid"), then:
        - SWH_Cor_Ku = SWH_Ku
        - Cor_Mis_Range_Ku = 0
        - Cor_Mis_Range_C = 0
        - Cor_Mis_SWH_Ku = 0
        - Cor_Mis_Sigma0_Ku = 0
        - Cor_Mis_Sigma0_C = 0
- Else (at least one flag among SWH_Ku_Val_Flag and Off_Nad2_Mean_Val_Flag is set to "invalid" or Off_Nad2_Mean < Thresh_Off_Nad2), then:
    - SWH_Cor_Ku_Val_Flag is set to "invalid"
    - SWH_Cor_Ku = SWH_Ku
    - Cor_Mis_Range_Ku = 0
    - Cor_Mis_Range_C = 0
    - Cor_Mis_SWH_Ku = 0
    - Cor_Mis_Sigma0_Ku = 0
    - Cor_Mis_Sigma0_C = 0

ACCURACY

N/A

COMMENTS

- In order to ensure the continuity of the corrections whatever the surface type is, the off-nadir angle information used will nominally be the one derived from the platform and not the one derived from the waveforms. Indeed, the one derived from the waveforms represents the mispointing of the altimeter antenna over ocean surfaces only.
- In the real time processing (see RD10), the corrections will be computed from the off-nadir angle information derived from the waveforms because platform data are not available.
- For the production of a Level 1b product, the information derived from the platform should be used.

REFERENCES

- **Ref. 1:** Effet du dépointage d'antenne sur la précision de la mesure de l'altimètre
  CNES 86/290 - CT/DRT/TIT/RL, 02/12/86

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ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz modeled corrections of the instrumental errors on the Ku and C bands altimetric estimates (altimeter range, altimeter range rate, significant waveheight and backscatter coefficient), using correction tables depending on significant waveheight and signal to noise ratio.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_SNR_01 - To compute the SNR from the on-board estimates":
    - Ku-band signal to noise ratio (1 Hz)
    - C-band signal to noise ratio (1 Hz)
    - Validity flag for the signal to noise ratio (Ku and C bands)
  - From "ALT_COR_GEN_01 - To compute the mispointing corrections":
    - Corrected significant waveheight and associated validity flag
    - Ku-band mispointing correction on the backscatter coefficient
    - C-band mispointing correction on the backscatter coefficient
- Dynamic auxiliary data: None

- Static auxiliary data:
  - Instrumental correction tables [(1)]:
    - Ku-band altimeter range correction table
    - C-band altimeter range correction tables (for 320 MHz and for 100 MHz)
    - Altimeter range rate correction table
    - Significant waveheight correction table
    - Ku-band backscatter coefficient correction table
    - C-band backscatter coefficient correction tables (for 320 MHz and for 100 MHz)
  - Processing parameters:
    - Default value for the inputs of the correction tables

Output data

- Ku-band modeled instrumental correction on the altimeter range (1 Hz)
- C-band modeled instrumental correction on the altimeter range (1 Hz)
- Modeled instrumental correction on the altimeter range rate (1 Hz)
- Modeled instrumental correction on the significant waveheight (1 Hz)
- Ku-band modeled instrumental correction on the backscatter coefficient (1 Hz)
- C-band modeled instrumental correction on the backscatter coefficient (1 Hz)

Mathematical statement

Principle

The imperfections of the altimeter components lead to errors on the altimetric estimates. To provide accurate measurements, a complete knowledge of these errors (source and quantization of their effects) is required.

The following errors are accounted for:

- errors of the on-board software
- errors due to the low-pass filtering before FFT
- errors due to the leakage spikes
- errors due to the on-board FFT
- errors due to the PTR

Nevertheless, the linearity of these errors is not obvious at all, and a separate correction for each effect is probably not consistent with the instrument behavior. An integrated modeling of these errors is thus necessary.

---

(1) Including features such as lower bound, upper bound and step for each input

All these effects are accounted for in a simulator, which provides correction tables depending on significant waveheight and signal to noise ratio. The correction $\Delta(x,y)$ corresponding to a given significant waveheight x and a given signal to noise ratio y, will be computed by bilinear interpolation of the corresponding correction table, i.e. by:

$$\begin{aligned}\Delta(x,y) = {} & \frac{(x_n - x)(y_n - y)}{s_x.s_y}.\Delta(x_p, y_p) + \frac{(x_n - x)(y - y_p)}{s_x.s_y}.\Delta(x_p, y_n) \\ & + \frac{(x - x_p)(y_n - y)}{s_x.s_y}.\Delta(x_n, y_p) + \frac{(x - x_p)(y - y_p)}{s_x.s_y}.\Delta(x_n, y_n)\end{aligned} \quad (1)$$

where:

- x_p and x_n are the abscissa just before and just after x, and s_x is the corresponding step (x_n - x_p)
- y_p and y_n are the abscissa just before and just after y, and s_y is the corresponding step (y_n - y_p)

Computation of the corrections

For each band, the processing is the following:

- Correction of the signal to noise ratio, by adding the mispointing correction on the backscatter coefficient to the signal to noise ratio
- Bilinear interpolation of the corresponding input correction tables versus the corrected significant waveheight and the corrected signal to noise ratio, as defined in (1).

ALGORITHM SPECIFICATION

For each parameter X (Ku-band altimeter range, C-band altimeter range, altimeter range rate, Ku band significant waveheight, Ku-band backscatter coefficient and C-band backscatter coefficient), the 1-Hz modeled correction of the instrumental errors is computed using mechanism "GEN_MEC_COR_04 - Computation of a modeled instrumental correction" (AD11), with the following inputs:

- Significant waveheight and validity flag:
  - Significant waveheight : SWH (m)
  - Validity flag for the significant waveheight [(2)] : SWH_Val_Flag (/)
- Signal to noise ratio and validity flag [(1)]
  - Signal to noise ratio : SNR (dB)
  - Validity flag for the signal to noise ratio [(2)] : SNR_Val_Flag (/)
- Mispointing correction on the backscatter coefficient [(1)] : Cor_Mis_Sigma0 (dB)

[(2)] 2 states: "valid" and "invalid"

[(1)] Ku-band or C-band parameter, according to the band of the processed parameter (X); Ku-band parameter for the altimeter range rate

- Default value for the inputs of the correction table:
  - SWH default value : SWH_Def (m)
  - SNR default value : SNR_Def (dB)
- Modeled instrumental correction table for X (3):
  - SWH lower bound : Min_SWH (m)
  - SWH upper bound : Max_SWH (m)
  - SWH step : Step_SWH (m)
  - SNR lower bound : Min_SNR (dB)
  - SNR upper bound : Max_SNR (dB)
  - SNR step : Step_SNR (dB)
  - Correction table : Tab [0:N_SWH-1][0:N_SNR-1] (same unit as X)

  with N_a=(Max_a-Min_a)/Step_a+1

The corresponding outputs consist of the correction and the execution status.

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

(3) The C-band altimeter range correction table and the C-band backscatter coefficient correction table will be selected according to the emitted bandwidth in C band (configuration data)

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ALT_COR_RAN_01 - To compute the internal path correction

DEFINITION, ACCURACY AND SPECIFICATION

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	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz internal path correction on the altimeter range, accounting in particular for the difference of travel between the transmission and the reference lines within the altimeter (POSEIDON-2 LTM calibration parameter).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tag (1 Hz)
- Computed data: None
- Dynamic auxiliary data:
  - Time-stamped POSEIDON-2 LTM calibration parameters (PTR), i.e. for each band (Ku, C):
    - Difference of travel between the transmission and the reference lines within the altimeter
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - Distance between the duplexer and the antenna reference point for Ku band
    - Distance between the duplexer and the antenna reference point for C band

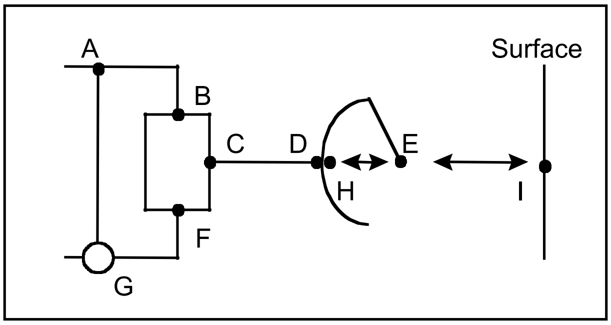
Output data

- Ku-band internal path correction on the altimeter range (1 Hz)
- C-band internal path correction on the altimeter range (1 Hz)

Mathematical statement

Principle

As represented in the figure below, the distance d measured by the altimeter is given by:



$$\begin{aligned} d &= (AB + BC + CD + DE) + EH + HI + IH + HE + (ED + DC + CF + FG) - AG \\ &= AB + BC + 2.CD + 2.DE + 2.EH + 2.HI + CF + FG - AG \end{aligned} \tag{1}$$

where points D and H are respectively outside and inside the antenna.

The altimeter range, i.e. the distance HI between the surface and the reference point of the antenna is thus:

$$HI = \frac{1}{2}\left(d - AB - BC - 2.CD - 2.DE - 2.EH - CF - FG + AG\right) \tag{2}$$

The difference of travel d_{cal} (distance) between the transmission and the reference lines provided by the internal calibration corresponds to:

$$d_{cal} = \frac{1}{2}\left(AB + BF + FG - AG\right) \tag{3}$$

Moreover, the following distance difference may be characterized on-ground before launch:

$$d_r = BC + CF - BF \tag{4}$$

The distances CE and EH may also be characterized before launch and thus a single parameter is requested from the POSEIDON-2 instrumental characterization data set to compute the internal correction path. This parameter represents the distance between the duplexer and the antenna reference point, and is given by:

$$d_{duplexer-antenna} = \frac{d_r}{2} + CE + EH \tag{5}$$

Combining (2) with (3) and (5), the altimeter range is given by:

$$HI = \frac{d}{2} - \left(d_{cal} + d_{duplexer-antenna}\right) \tag{6}$$

In this equation, d/2 represents the raw value of the altimeter range and the internal path correction to be added to this value is thus:

$$\Delta h = -\left(d_{cal} + d_{duplexer-antenna}\right) \tag{7}$$

Computation of the internal path correction

For each band, the processing is the following:

- Selection of the d_{cal} calibration parameter (calibration point just before the measurement time-tag)
- Computation of the correction Δh according to (7).

ALGORITHM SPECIFICATION

Warning: The selection of the difference of travel between the transmission and the reference lines (calibration parameter, Ku and C bands) for each averaged measurement, is considered as a "data management" algorithm (see section 1). It is specified in RD11.

The computation of the 1-Hz internal path correction on the altimeter range for Ku band or for C band, is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- PTR calibration parameters (selected) [Ku/C]:
  - Difference of travel between the transmission and the reference lines : Dif_TR (m)
- POSEIDON-2 instrumental characterization data [Ku/C]:
  - Distance duplexer / antenna reference point : Dif_DA (m)

Output data

- Internal path correction on the altimeter range [Ku/C] : Cor_Path_Range (m)
- Execution status

Processing

The internal path correction on the altimeter range is computed by:

$$\text{Cor\_Path\_Range} = -(\text{Dif\_TR} + \text{Dif\_DA}) \quad (1)$$

ACCURACY

N/A

COMMENTS

None

REFERENCES

None

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ALT_COR_RAN_02 - To compute the Doppler correction

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

None

FUNCTION

To compute the 1-Hz Doppler corrections on the altimeter range.

APPLICABILITY

JASON-1 (and ENVISAT, see RD4).

ALGORITHM DEFINITION

Input data

- Product data:
  - Orbital altitude rate (1 Hz)
  - Altimeter configuration data
- Computed data: None
- Dynamic auxiliary data: None
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data, i.e. for each band (Ku, C):
    - Emitted frequency
    - Pulse duration
    - Emitted bandwidth (depending on the altimeter configuration data)
    - Sign of the slope of the transmitted chirp

Output data

- Ku-band Doppler correction (1 Hz)
- C-band Doppler correction (1 Hz)

Mathematical statement

For each band, the Doppler correction to be added to the altimeter range is computed by:

$$\Delta h_{Doppler} = -\varepsilon.\frac{f.T}{B}.h' \qquad (1)$$

where:

- h' is the altitude rate
- f is the emitted frequency
- T is the pulse duration
- B is the emitted bandwidth
- $\varepsilon = \pm 1$ is the sign of the slope of the transmitted chirp

ALGORITHM SPECIFICATION

For each averaged measurement, the computation of the 1-Hz Doppler correction on the altimeter range (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Orbital altitude rate : Orb_Alt_Rate (m/s)
- Instrumental characterization data:
  - Emitted frequency (1) : Frequency (Hz)
  - Pulse duration : Pulse_Duration (s)
  - Emitted bandwidth (2) : Bandwidth (Hz)
  - Sign of the slope of the transmitted chirp : Sign_Slope (-1 or +1)

Output data

- Doppler correction [Ku/C] : Cor_Dop_Range (m)
- Execution status

Processing

The Doppler correction is computed using mechanism "GEN_MEC_COR_03 - Computation of the Doppler correction on the altimeter range" (AD11), with the inputs mentioned above.

ACCURACY

See RD4 - "ALT_COR_RAN_02 - To compute the Doppler correction".

(1) Value to be selected according to the processed band

(2) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

COMMENTS

- In order to ensure the continuity of the Doppler correction whatever the surface type is, the altitude rate involved in its expression originates from the orbit, and is not the tracker estimate or an estimate derived from the altimeter range retracked estimates (e.g. slope of these estimates over 1 second, as it was done for POSEIDON-1).
- The part of the altitude rate due to the variation of the sea surface height (geoid or mean sea surface with respect to ellipsoid) is not accounted for in the level 1b Doppler correction.

REFERENCES

Chelton D.B., Walsh E.J., and MacArthur J.L., 1989, Pulse compression and sea-level tracking in satellite altimetry, J. Atmos. Oceanic Technol., 6, 407-438.

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ALT_COR_RAN_03 - To compute the corrected tracker ranges

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To compute the 20-Hz and the 1-Hz Ku and C bands corrected tracker ranges.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tags (1 Hz)
- Computed data:
  - From "ALT_PHY_RAN_02 - To compute the tracker ranges", for Ku and C bands
    - Tracker range and associated validity flag (20 Hz)
  - From "ALT_COM_RAN_01 - To edit and compress the tracker ranges", for Ku and C bands:
    - Tracker range and associated validity flag (1 Hz)
  - From "ALT_COR_RAN_01 - To compute the internal path correction":
    - Ku-band and C-band internal path corrections on the altimeter range
- Dynamic auxiliary data:
  - Platform data and associated time-tags:
    - Distance antenna-COG
- Static auxiliary data: None

Output data

- Ku-band corrected tracker ranges (1 Hz and 20 Hz)
- C-band corrected tracker ranges (1 Hz and 20 Hz)
- Distance antenna – COG (1 Hz)

Mathematical statement

The distance antenna - COG corresponding to each 1-Hz input altimeter measurement is the closest value which precedes the altimeter time-tag. This selected value is constant over an averaged measurement.

The 20-Hz and the 1-Hz estimates of the Ku and C band tracker ranges are already corrected for the USO frequency drift. The following two corrections are added:

- the internal path correction (1)
- the distance antenna - COG (1)

Notes

(1) Correction which does not depend on the processing level (1b, IGDR, GDR)

ALGORITHM SPECIFICATION

Warning: The selection of the distance antenna - COG for each altimeter time-tag is considered as a "data management" algorithm (see section 1). It is specified in RD11.

The computation of the corrected tracker ranges (Ku or C band, 20-Hz or 1-Hz) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- Tracker range and validity flag [Ku/C]:
  - Tracker range : Trk_Range (m)
  - Tracker range validity flag [(1)] : Trk_Range_Val_Flag (/)
- Corrections on the tracker range:
  - Distance antenna - COG (selected) : Ant_COG (m)
  - Internal path correction [Ku/C] : Cor_Path_Range (m)

Output data

- Corrected tracker range [Ku/C] : Trk_Range_Cor (m)
- Execution status

[(1)] 2 states: "valid" or "invalid"

Processing

The corrected tracker range is computed using mechanism "GEN_MEC_COR_02 - Computation of a corrected parameter from its raw value and its corrections" (AD11), with the following inputs:

- Raw value : Trk_Range
- Validity flag of the raw value : Trk_Range_Val_Flag
- Number of corrections : 2
- Corrections: : Ant_COG
  Cor_Path_Range

ACCURACY

TBD

COMMENTS

None

REFERENCES

None

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ALT_COR_RAN_04 - To compute the corrected on-board retracked altimeter ranges

DEFINITION, ACCURACY AND SPECIFICATION

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HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz Ku and C bands corrected on-board retracked altimeter ranges.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter time-tags (1 Hz)
  - Altimeter configuration data
- Computed data:
  - From "ALT_COM_RAN_04 - To edit and compress the on-board retracked altimeter ranges", for Ku and C bands:
    - On-board retracked altimeter ranges and associated validity flag (1 Hz)
  - From "ALT_COR_GEN_01 - To compute the mispointing corrections":
    - Ku-band and C-band mispointing corrections on the altimeter range
  - From "ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters":
    - Ku-band and C-band altimeter range modeled instrumental corrections
  - From "ALT_COR_RAN_01 - To compute the internal path correction":
    - Ku-band and C-band internal path corrections on the altimeter range
  - From "ALT_COR_RAN_02 - To compute the Doppler correction":
    - Ku-band and C-band Doppler corrections
- Dynamic auxiliary data:
  - Platform data and associated time-tags:
    - Distance antenna-COG

- Static auxiliary data:
  - Processing parameters for the correction of the on-board retracked altimeter ranges:
    - Ku-band and C-band altimeter range system biases

Output data

- Ku-band corrected on-board retracked altimeter ranges (1 Hz)
- C-band corrected on-board retracked altimeter ranges (1 Hz)

Mathematical statement

The distance antenna - COG corresponding to each 1-Hz input altimeter measurement is the closest value which precedes the altimeter time-tag (see "ALT_COR_RAN_03 - To compute the corrected tracker ranges"). This selected value is constant over an averaged measurement.

The 1-Hz estimates of the Ku and C band on-board retracked altimeter ranges are already corrected for the USO frequency drift. The following six corrections are added:

- the internal path correction (1)
- the distance antenna - COG (1)
- the Doppler correction (2)
- the modeled instrumental correction (3)
- the mispointing correction (4)
- the system bias

Notes

(1) Correction which does not depend on the processing level (1b, IGDR, GDR)
(2) Correction which is applicable to level 1b processing only, and which will be updated in the level 2 processing (IGDR, GDR)
(3) Correction which is applicable to level 1b processing only, and which will be recomputed in the level 2 processing (IGDR) accounting for a different retracking algorithm and ignoring the low-pass filter effects.
(4) Correction which is applicable to level 1b processing only, and which have no equivalence in the level 2 processing (IGDR) where the mispointing is accounted for through the retracking algorithm.

ALGORITHM SPECIFICATION

Warning: The selection of the distance antenna - COG for each altimeter time-tag is considered as a "data management" algorithm (see "ALT_COR_RAN_03 - To compute the corrected tracker ranges"). It is specified in RD11.

The computation of the 1-Hz corrected on-board retracked altimeter ranges (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- On-board retracked altimeter range and validity flag [Ku/C]:
  - On-board retracked altimeter range : Retrk_Range (m)
  - On-board retracked altimeter range validity flag (1) : Retrk_Range_Val_Flag (/)
- Corrections on the on-board retracked altimeter range:
  - Internal path correction [Ku/C] : Cor_Path_Range (m)
  - Distance antenna - COG (selected) : Ant_COG (m)
  - Doppler correction [Ku/C] : Cor_Dop_Range (m)
  - Modeled instrumental correction [Ku/C] : Cor_Mod_Range (m)
  - Mispointing correction [Ku/C] : Cor_Mis_Range (m)
  - System bias [Ku/C] (2) : Sys_Bias_Range (m)

Output data

- Corrected on-board retracked altimeter range [Ku/C] : Retrk_Range_Cor (m)
- Execution status

Processing

The corrected on-board retracked altimeter range is computed using mechanism "GEN_MEC_COR_02 - Computation of a corrected parameter from its raw value and its corrections" (AD11), with the following inputs:

- Raw value : Retrk_Range
- Validity flag of the raw value : Retrk_Range_Val_Flag
- Number of corrections : 6
- Corrections: : Cor_Path_Range
  Ant_COG
  Cor_Dop_Range
  Cor_Mod_Range
  Cor_Mis_Range
  Sys_Bias_Range

(1) 2 states: "valid" or "invalid"

(2) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

ACCURACY

TBD

COMMENTS

- The possible correction of the 20-Hz estimates of the on-board retracked altimeter range will be accounted for, if any, within the process aimed at building the level 1b product, either by adding the appropriate 1-Hz corrections or by coding these estimates as differences with respect to the 1-Hz estimates.

REFERENCES

None

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ALT_COR_RAN_05 - To compute the corrected tracker range rates

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
Checked by:	For the JASON-1 SWT M. SROKOSZ E. RODRIGUEZ For the JASON-1 Project P. VINCENT CNES S. DESAI JPL	
Approved by:	P. VINCENT CNES	

Document ref:	SMM-ST-M2-EA-11003-CN	18th October, 2001	Issue: 3	Update: 2

Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz corrected tracker range rates.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data: None
- Computed data:
  - From "ALT_COM_RAN_03 - To edit and compress the tracker range rates":
    - Tracker range rate and associated validity flag (1 Hz)
  - From "ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters":
    - Altimeter range rate modeled instrumental correction
- Dynamic auxiliary data: None
- Static auxiliary data: None

Output data

- Corrected tracker range rate (1 Hz)

Mathematical statement

The modeled instrumental correction is added to the input tracker range rate.

ALGORITHM SPECIFICATION

The computation of the 1-Hz corrected tracker range rate is specified hereafter.

Input data

- Tracker range rate and validity flag:
  - Tracker range rate : Trk_Range_Rate (m/s)
  - Tracker range rate validity flag (1) : Trk_Range_Rate_Val_Flag (/)
- Corrections on the tracker range rate:
  - Modeled instrumental correction : Cor_Mod_Trk_Range_Rate (m/s)

Output data

- Corrected tracker range rate : Trk_Range_Rate_Cor (m/s)
- Execution status

Processing

The corrected tracker range rate is computed using mechanism "GEN_MEC_COR_02 - Computation of a corrected parameter from its raw value and its corrections" (AD11), with the following inputs:

- Raw value : Trk_Range_Rate
- Validity flag of the raw value : Trk_Range_Rate_Val_Flag
- Number of corrections : 1
- Corrections: : Cor_Mod_Trk_Range_Rate

ACCURACY

TBD

COMMENTS

None

REFERENCES

None

(1) 2 states: "valid" or "invalid"

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ALT_COR_SWH_01 - To compute the corrected on-board retracked significant waveheights

DEFINITION, ACCURACY AND SPECIFICATION

Prepared by:	J.P. DUMONT CLS	
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Document ref:	SMM-ST-M2-EA-11003-CN	18th October, 2001	Issue: 3	Update: 2

Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz Ku-band corrected on-board retracked significant waveheights.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Significant waveheight and associated validity flag (1 Hz)
- Computed data:
  - From "ALT_COR_GEN_01 - To compute the mispointing corrections":
    - Mispointing correction on the significant waveheight
  - From "ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters":
    - Significant waveheight modeled instrumental correction
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Processing parameters:
    - Significant waveheight system bias

Output data

- Ku-band corrected significant waveheight (1 Hz)

Mathematical statement

The following three corrections are added to the input significant waveheight:

- the modeled instrumental correction (3)
- the mispointing correction (4)
- the system bias

Notes

(3) Correction which is applicable to level 1b processing only, and which will be recomputed in the level 2 processing (IGDR) accounting for a different retracking algorithm and ignoring the low-pass filter effects.

(4) Correction which is applicable to level 1b processing only, and which have no equivalence in the level 2 processing (IGDR) where the mispointing is accounted for through the retracking algorithm.

ALGORITHM SPECIFICATION

The computation of the 1-Hz corrected on-board retracked significant waveheight (Ku-band) is specified hereafter.

Input data

- On-board retracked significant waveheight and validity flag:
  - On-board retracked significant waveheight : SWH (m)
  - On-board retracked significant waveheight validity flag [1] : SWH_Val_Flag (/)
- Corrections on the on-board retracked significant waveheight:
  - Modeled instrumental correction : Cor_Mod_SWH (m)
  - Mispointing correction : Cor_Mis_SWH (m)
  - System bias : Sys_Bias_SWH (m)

Output data

- Corrected on-board retracked significant waveheight : SWH_Cor (m)
- Execution status

Processing

The corrected on-board retracked significant waveheight is computed using mechanism "GEN_MEC_COR_02 - Computation of a corrected parameter from its raw value and its corrections" (AD11), with the following inputs:

- Raw value : SWH
- Validity flag of the raw value : SWH_Val_Flag
- Number of corrections : 3
- Corrections: : Cor_Mod_SWH
  Cor_Mis_SWH
  Sys_Bias_SWH

[1] 2 states: "valid" or "invalid"

ACCURACY

TBD

COMMENTS

None

REFERENCES

None

Affaires Techniques Projets et Services Opérationnels
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ALT_COR_BAC_01 - To compute the corrected on-board retracked backscatter coefficients

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

Title: ALT_COR_BAC_01 - To compute the corrected on-board retracked backscatter coefficients

Definition, Accuracy and Specification

HERITAGE

POSEIDON-1

FUNCTION

To compute the 1-Hz Ku and C bands corrected on-board retracked backscatter coefficients.

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Altimeter configuration data
- Computed data:
  - From "ALT_PHY_BAC_03 - To compute the on-board retracked backscatter coefficients", for Ku and C bands:
    - On-board retracked backscatter coefficients and associated validity flag (1 Hz)
  - From "ALT_COR_GEN_01 - To compute the mispointing corrections":
    - Ku-band and C-band mispointing corrections on the backscatter coefficient
  - From "ALT_COR_GEN_02 - To compute the modeled instrumental corrections on the on-board retracked parameters":
    - Ku-band and C-band backscatter coefficient modeled instrumental corrections
- Dynamic auxiliary data: None
- Static auxiliary data:
  - Processing parameters:
    - Ku-band and C-band backscatter coefficient system biases

Output data

- Ku-band corrected on-board retracked backscatter coefficients (1 Hz)
- C-band corrected on-board retracked backscatter coefficients (1 Hz)

Mathematical statement

The 1-Hz estimate of the on-board retracked backscatter coefficients is already corrected for the AGC errors, the internal calibration and the SSPA temperatures effects. The following three corrections are added:

- the modeled instrumental correction (3)
- the mispointing correction (4)
- the system bias

Notes

(3) Correction which is applicable to level 1b processing only, and which will be recomputed in the level 2 processing (IGDR) accounting for a different retracking algorithm and ignoring the low-pass filter effects.

(4) Correction which is applicable to level 1b processing only, and which have no equivalence in the level 2 processing (IGDR) where the mispointing is accounted for through the retracking algorithm.

ALGORITHM SPECIFICATION

The computation of the 1-Hz corrected on-board retracked backscatter coefficients (Ku-band or C-band) is specified hereafter.

Symbol [Ku/C] associated with a parameter or with a set of parameters means that this (set of) parameter(s) is defined twice (Ku-band and C-band value(s)).

Input data

- On-board retracked backscatter coefficient and validity flag [Ku/C]:
  - On-board retracked backscatter coefficient : Retrk_Sigma0 (dB)
  - On-board retracked backscatter coefficient validity flag (1) : Retrk_Sigma0_Val_Flag (/)
- Corrections on the on-board retracked backscatter coefficient:
  - Modeled instrumental correction [Ku/C] : Cor_Mod_Sigma0 (dB)
  - Mispointing correction [Ku/C] : Cor_Mis_Sigma0 (dB)
  - System bias [Ku/C] (2) : Sys_Bias_Sigma0 (dB)

Output data

- Corrected on-board retracked backscatter coefficient [Ku/C] : Retrk_Sigma0_Cor (dB)
- Execution status

(1) 2 states: "valid" or "invalid"

(2) Value to be selected according to the processed band and the emitted bandwidth (altimeter configuration data)

Processing

The corrected on-board retracked backscatter coefficient is computed using mechanism "GEN_MEC_COR_02 - Computation of a corrected parameter from its raw value and its corrections" (AD11), with the following inputs:

- Raw value : Retrk_Sigma0
- Validity flag of the raw value : Retrk_Sigma0_Val_Flag
- Number of corrections : 3
- Corrections: : Cor_Mod_Sigma0
  Cor_Mis_Sigma0
  Sys_Bias_Sigma0

ACCURACY

TBD

COMMENTS

None

REFERENCES

None

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Algorithm to be defined in a further issue

ALT_COR_WAV_01 - To correct the waveforms for the filtering effects

DEFINITION, ACCURACY AND SPECIFICATION

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Algorithm change record	creation	date	Issue:	Update:
	CCM			

HERITAGE

None

FUNCTION

To correct the Ku and C band waveforms for the effect of the low-pass filtering (POSEIDON-2 LTM calibration parameters).

APPLICABILITY

JASON-1

ALGORITHM DEFINITION

Input data

- Product data:
  - Ku-band waveforms (20 Hz - 128 samples)
  - C-band waveforms (20 Hz - 128 or 40 samples)
  - Ku-band waveforms validity flags (20 Hz)
  - C-band waveforms validity flags (20 Hz)
  - Altimeter time-tag (1 Hz)
  - Altimeter configuration data
- Computed data:
  - TBC From "ALT_PHY_RAN_01 - To restore the on-board coarse and fine trigger delays":
    - Fine trigger delay applied on-board to each pulse (j) of each waveform (counter): $\{TD_f(j)\}$
- Dynamic auxiliary data:
  - Time-stamped POSEIDON-2 LTM calibration parameters (LPF), i.e. for each band (Ku, C):
    - Normalized filter [(1)]: f
- Static auxiliary data:
  - POSEIDON-2 instrumental characterization data:
    - TBC Fine trigger delay resolution, depending on the emitted bandwidth: δt_{FTD} (in time) or δf_{FTD} (in frequency)

[(1)] Three filters are provided: one Ku-band filter, one C-band filter corresponding to a 320-MHz bandwidth, and one C-band filter corresponding to a 100-MHz bandwidth.

Output data

- Ku-band corrected waveforms (20 Hz - 128 samples)
- C-band corrected waveforms (20 Hz - 128 or 40 samples)

Mathematical statement

In order to be able to determine the effects of the filtering on each pulse of a waveform, the input filter f has been oversampled within the on-ground calibration process with a step δf_{FTD} equal to the fine trigger delay resolution.

The effect of the filtering on each sample $V_j[t(i)]$ (expressed versus time) of a pulse j is a weighting factor equal to:

$$f[t(i) + N(j).\delta t_{FTD}] \qquad (1)$$

where:

- $N(j) = TD_f(j)$ for a Ku-band pulse or C-band pulse with a bandwidth of 320 MHz
- $N(j) = \frac{TD_f(j)}{3.2}$ converted in integer (as on-board) for a C-band pulse with a 100 MHz bandwidth

The corresponding sample V[t(i)] of the waveform built by averaging of N_p pulses (N_p depending on the Ku/C band sequencing) may thus be expressed by:

$$V[t(i)] = \frac{\sum_j V_j[t(i)].f[t(i) + N(j).\delta t_{FTD}]}{N_p} \qquad (2)$$

Values $V_j[t(i)]$ are affected by speckle but this effect is unknown. Indeed, the only information available on-ground is the averaged speckle affecting V[t(i)].

Ignoring the speckle effects, each sample V[t(i)] of the waveform will thus be corrected by (TBC):

$$V_{corrected}[t(i)] = V[t(i)].\frac{N_p}{\sum_j f[t(i) + N(j).\delta t_{FTD}]} \qquad (3)$$

These operations will be applied to Ku and C bands data, from the corresponding input filter which precedes the altimeter measurement.

ALGORITHM SPECIFICATION

Input data

- TBD

Output data

- TBD
- Execution status

Processing

TBD

ACCURACY

N/A

COMMENTS

- The accounting for the fine trigger delays in the processing is TBC.
- C-band waveforms consist of 128 samples if the emitted bandwidth is 320 MHz, and 40 samples if the emitted bandwidth is 100 MHz.

REFERENCES

None

APPENDIX 1

MANAGEMENT OF THE INSTRUMENTAL CORRECTIONS IN THE JASON-1 ALTIMETER PROCESSING

This appendix is aimed at clarifying the management of instrumental corrections in the JASON-1 altimeter processing, in the particular case of the following production scenario (which does not anticipate the organization or the sequencing of the algorithms within the CMA processor):

1) production of level 1b products from level 1.0 products
2) production of IGDR products from level 1b products
3) production of GDR products from IGDR products

The level 2 procedures (IGDR and GDR) are defined in RD4.

The main parameters output by the JASON-1 altimeter processing (Level 1b, IGDR, GDR) are the following:

- **Tracker ranges (20 Hz and 1 Hz, Ku and C bands)**

  These parameters are corrected for:

  – the USO frequency drift (1 Hz)

  – the internal path correction (1 Hz), accounting in particular for the difference of travel between the transmission and the reference lines within the altimeter (internal calibration correction)

  – the distance antenna - COG (1 Hz)

  These corrections are applied in the level 1b processing. The corrected tracker ranges are not updated in the level 2 processing (IGDR, GDR). The tracker range estimates do not account for the correction of the Doppler effects.

  [Only for CMA specifiers and developers, do not forget that:

  For ENVISAT:

  – Level 1b products consist of 20-Hz records. The 20-Hz tracker range level 1b estimates are corrected for the Doppler effects, using the orbital altitude rate computed from the orbit data available for the level 1b processing. These 20-Hz corrections are removed in the IGDR processing, leading in the level 2 products to 20-Hz tracker range estimates without correction for the Doppler effects.

  – Be aware also that the distance antenna - COG is added to the level 1b input tracker ranges in the IGDR processing.]

- **Tracker range rates (1 Hz)**

  These parameters are corrected for:

  – the modeled instrumental correction (1 Hz)

  This correction is applied in the level 1b processing. It is computed from a table built from a simulator of the altimeter and of the on-board retracking algorithm. The corrected tracker range rate is updated in the level 2 processing (IGDR, GDR) to account for the refined estimates of the significant waveheight and of the signal to noise ratio (inputs of the correction table).

- **On-board/ground retracked altimeter ranges (20 Hz and 1 Hz, Ku and C bands)**

  These parameters are corrected for:

  – the USO frequency drift (1 Hz)

- the internal path correction (1 Hz)
- the distance antenna - COG (1 Hz)
- the Doppler correction (1 Hz)
- the mispointing correction (1 Hz): Level 1b only
- the modeled instrumental correction (1 Hz)
- the system bias (1 Hz)

The retracked altimeter ranges result from the combination of:

- the tracker ranges, corrected in the level 1b processing for the USO frequency drift, the internal path correction and the distance antenna - COG
- the position of the waveform in the analysis window (epoch) provided by the retracking algorithm (on-board retracking for level 1b parameters, on-ground retracking for level 2 parameters).

Doppler correction

In the level 1b processing, the 1-Hz Doppler corrections are computed from the orbital altitude rate provided in the level 1.0 input product. These corrections are recomputed and the corrected altimeter range are updated in the IGDR and possibly in the GDR processing (see RD4), accounting for preliminary and precise orbit data.

[In the ENVISAT processing, Doppler corrections are computed and applied to 20-Hz measurements (i.e. before the 1-Hz compression process) because the emitted bandwidth for Ku band (320 MHz, 80 MHz or 20 Hz) may change within a 1-Hz measurement.]

Mispointing correction

In the level 1b processing, the mispointing corrections are computed from models depending on the significant waveheight and the square of the off-nadir angle (interpolated platform data or possibly waveforms-derived data).

These corrections are not relevant to IGDR and GDR parameters (for JASON-1 and for ENVISAT), because in the IGDR processing, mispointing is accounted for through the on-ground retracking algorithm.

Modeled instrumental correction

In the level 1b processing, the modeled instrumental corrections are computed from tables which are built from a simulator of the altimeter and from the on-board retracking algorithm. These tables represent a global modeling of the instrumental errors due to the imperfections of the altimeter components (errors of the on-board software, errors due to the low-pass filtering before FFT, errors due to the leakage spikes, errors due to the on-board FFT, errors due to the PTR). They account in particular for all the instrumental features provided by the POSEIDON-2 internal calibration (PTR and LPF). Input parameters for these tables are the signal to noise ratio derived in the level 1b processing from the on-board estimates, and the on-board estimate of the significant waveheight (corrected for the mispointing effects).

These corrections are recomputed and the altimeter ranges are updated in the IGDR processing, using different tables accounting for the on-ground retracking algorithm and ignoring the low-pass filter effects (as the level 1b waveforms are already corrected for them). Input parameters for these tables are the signal to noise ratio estimated in the IGDR processing from the averaged on-ground estimates of the waveforms amplitude and thermal noise level, and the averaged on-ground estimate of the significant waveheight.

[Regarding ENVISAT, this type of corrections is performed in the level 1b processing only.]

System bias

The system bias added to the altimeter range estimates in the level 1b processing is aimed at providing data sets consistent with data sets issued from a reference mission (e.g. TOPEX). This system bias is susceptible of being updated in the IGDR processing, to account for differences between both processing.

- **Net instrumental correction on the altimeter range (1 Hz, Ku and C bands)**

  In the IGDR and GDR products, the net instrumental correction on the altimeter range will be the sum of the following corrections:

  – the USO frequency drift (1 Hz)

  – the internal path correction, including the internal calibration correction (1 Hz)

  – the distance antenna - COG (1 Hz)

  – the Doppler correction (1 Hz)

  – the modeled instrumental correction (1 Hz)

  – the system bias (1 Hz)

  The mispointing correction is not accounted for as it is irrelevant for level 2 parameters.

- **On-board/ground significant waveheight (1 Hz, Ku and C bands)**

  These parameters are corrected for:

  – the mispointing correction (1 Hz): Level 1b only

  – the modeled instrumental correction (1 Hz)

  – the system bias (1 Hz)

  The level 1b significant waveheight is the Ku-band estimate derived from the on-board retracking. In the IGDR and GDR products, the significant waveheight estimates are issued from the on-ground retracking in both bands (Ku and C).

  For the same reasons as for the retracked altimeter ranges:

  – the mispointing corrections computed in the level 1b processing are not relevant to level 2 parameters

  – the modeled instrumental corrections computed in the level 1b processing are recomputed and the corrected significant waveheights are updated in the IGDR processing

  – the system biases computed in the level 1b processing are susceptible of being updated in the IGDR processing

- **Net instrumental correction on the significant waveheight (1 Hz, Ku and C bands)**

  In the IGDR and GDR products, the net instrumental correction on the significant waveheight will be the sum of the following corrections:

  – the modeled instrumental correction (1 Hz)

  – the system bias (1 Hz)

  The mispointing correction is not accounted for as it is irrelevant for level 2 parameters.

- **AGC (20 Hz and 1 Hz, Ku and C bands)**

  These parameters are corrected for:

  – the AGC errors (20 Hz), i.e. the difference between the transmitted value and the value applied on-board

  The corrected AGCs are computed in the level 1b processing. They are not updated in the level 2 processing (IGDR, GDR).

- **Scaling factors for Sigma0 evaluation (20 Hz, Ku and C bands)**

  These parameters, which represent the backscatter coefficients corresponding to a retracked amplitude equal to 1, are corrected for:

  – the AGC errors (20 Hz)

  – the internal calibration (1 Hz)

  The corrected scaling factors for Sigma0 evaluation are computed in the level 1b processing. They are not updated in the level 2 processing (IGDR, GDR).

- **On-board/ground retracked backscatter coefficient (1 Hz, Ku and C bands)**

  These parameters are corrected for:

  – the AGC errors (20 Hz)

  – the internal calibration (1 Hz)

  – the mispointing correction (1 Hz): Level 1b only

  – the modeled instrumental correction (1 Hz)

  – the system bias (1 Hz)

  In the level 1b processing, the (raw) retracked backscatter coefficients are computed from on-board estimates (AGC combined with the on-board retracked amplitude of the waveforms), corrected for the AGC errors. The internal calibration corrections are accounted for in the level 1b processing.

  In the level 2 processing, the (raw) retracked backscatter coefficients result from the combination of:

  – the scaling factors for Sigma0 evaluation, corrected in the level 1b processing for the AGC errors and the internal calibration

  – the amplitude of the waveform in the analysis window provided by the on-ground retracking algorithm

  For the same reasons as for the retracked altimeter ranges:

  – the mispointing corrections computed in the level 1b processing are not relevant to level 2 parameters

  – the modeled instrumental corrections computed in the level 1b processing are recomputed and the corrected backscatter coefficients are updated in the IGDR processing

  – the system biases computed in the level 1b processing are susceptible of being updated in the IGDR processing

- **Net instrumental correction on the backscatter coefficients (1 Hz, Ku and C bands)**

  In the IGDR and GDR products, the net instrumental correction on the backscatter coefficients will be the sum of the following corrections:

  – the AGC errors (1 Hz)

  – the internal calibration (1 Hz)

  – the modeled instrumental correction (1 Hz)

  – the system bias (1 Hz)

  The mispointing correction is not accounted for as it is irrelevant for level 2 parameters.

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